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OBSERVATIONS ON NEOVOSSIA INDICA[1]

C. S. HOLTON [2]

(Accepted for publication, March 30, 1949)

NEOVOSSIA indica (Mitra) Mundkur (6) (*Tilletia indica* Mitra) (3) causes the partial bunt of wheat, which occurs in India. The basic characteristics of this fungus have been established by the investigations of Mitra (3, 4, 5) and Mundkur (6, 7, 8). Although the partial bunt clearly is distinct from the common and dwarf bunts caused by *Tilletia caries* (DC.) Tul. there is some similarity between these diseases and their respective causal organisms. For this reason studies were undertaken to elucidate the fundamental differences and similarities between them. These studies included observations on morphology, chlamydospore germination, growth on culture media, nuclear behavior, and hybridization.[3] All of the work was confined to the laboratory and greenhouse.

CHLAMYDOSPORE GERMINATION

The chlamydospores of *Neovossia indica* are reticulate like those of *Tilletia caries* but they are larger and darker in color. The spores germinated in 7 days on 2 per cent water agar at room temperature (approximately 22° C.) following a presoaking treatment of one week in tap water, also at room temperature. In general, this confirms the observations of Mitra (4, 5) and Mundkur (7) who obtained spore germination at 15°—25° C. after special pre-treatment.

Spore germination in *Neovossia indica* takes place by the production of un branched promycelia on the tips of which are borne large numbers of primary sporidia. The promycelial length has a wide range, in some instances barely emerging from the spore and in others attaining a length of several hundred microns. In long promycelia the protoplasm is concentrated toward the unicellular apical end, leaving the multicellular basal portion empty. This, in general, confirms the observations of Mitra (4). He found that the promycelia ranged in length from 10 to 1500 microns and sometimes were branched. The number of sporidia varies greatly, actual counts on seven promycelia ranging from 26 to 171, the average being 117. Mitra (4) likewise observed that this species produces large numbers of sporidia, ranging from 32 to 128. True branching of the promycelia, such as that which occurs in dwarf bunt (1), does not occur in the promycelia of *N. indica*. However, a type of branching similar to that described for *T. caries* by Kienholz and Heald (2) does occur. The type occurring in dwarf bunt may be regarded as true branching, since sporidia are borne on the branches. In contrast, the type described by Kienholz and Heald (2) should be interpreted as false branching, since sporidia eventually are borne on only one branch. The promycelial branching in *N. indica* reported by Mitra (4) probably was what is here regarded as false branching.

Fusion of primary sporidia to form H-shaped structures usually does not occur in species of *Neovossia*. Mitra (4) and Mundkur (8) observed no fusions between sporidia of *N. indica*. The writer has examined many hundreds of primary sporidia

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1. Co-operative investigations of the Division of Cereal Crops and Diseases, Bureau of Plant Industry, Soils and Agricultural Engineering, Agr. Res. Admin., U. S. Department of Agriculture, and the Washington Agricultural Experiment Station.

2. Pathologist, Division of Cereal Crops and Diseases, Bureau of Plant Industry, Soils and Agricultural Engineering.

3. The spore material of *Neovossia indica* was obtained from Dr A. G. Johnson, Plant Industry Station, Beltsville, Maryland, who had received it from Dr B. B. Mundkur, New Delhi, India. The specimens had been collected by M. A. Khan at Karnal, India, April 20, 1942.

of this species in all stages of development and only one pair of fused sporidia has been observed. This is the only reported instance of fusion between two primary sporidia to form an H-shaped structure in this species. However, the infrequency of its occurrence may be regarded as confirmation of other observations (4), that the primary sporidia generally do not fuse.

CULTURE CHARACTERS

Cultures of monosporidial lines were obtained by isolating primary sporidia

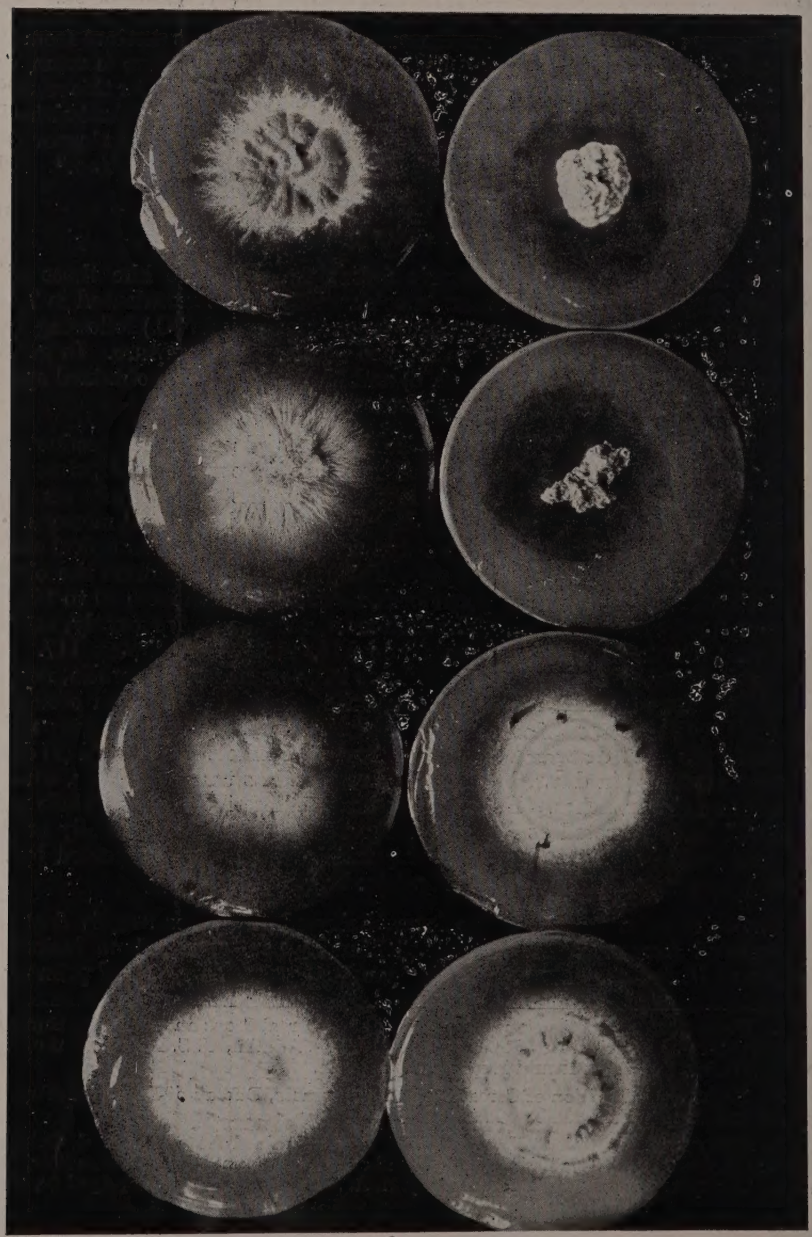

Fig. 1. Eight culture types found in *N. indica*

from the promycelia of germinating chlamydospores with the aid of a Chambers micromanipulator. The isolated primary sporidia of *Neovossia indica* grow readily in culture and it was possible to obtain almost complete sets of sporidia from individual promycelia. In one instance 152 monosporidial lines were obtained from a promycelium that produced 166 sporidia. The isolated primary sporidia grow rapidly and develop mycelial colonies which produce secondary sporidia. The expanded colonies resemble those of *Tilletia caries*. It was notable that the secondary sporidia in certain monosporidial lines were larger than those in other monosporidial lines.

Ninety monosporidial lines from one promycelium were grown on potato dextrose agar in flasks for the purpose of comparing growth types. At least 8 distinct culture types were recognizable in this group. These are illustrated in Figure 1. The colony types ranged from dark to light in color, small to large in size, brittle to leathery in texture, and sporidial to mycelial in growth type. In all cases there were intermediate types between the extremes. Similar observations were made by Ramamoorthy and Mundkur (9), who described culture characters of *Neovossia indica* obtained by isolating single secondary sporidia. Sectoring (Figure 2) occurred in many of the lines and the characteristics exhibited by the sectors proved to be permanently distinct from the parent lines. This is regarded as evidence that genetic changes, probably mutations, occur frequently in *N. indica*.

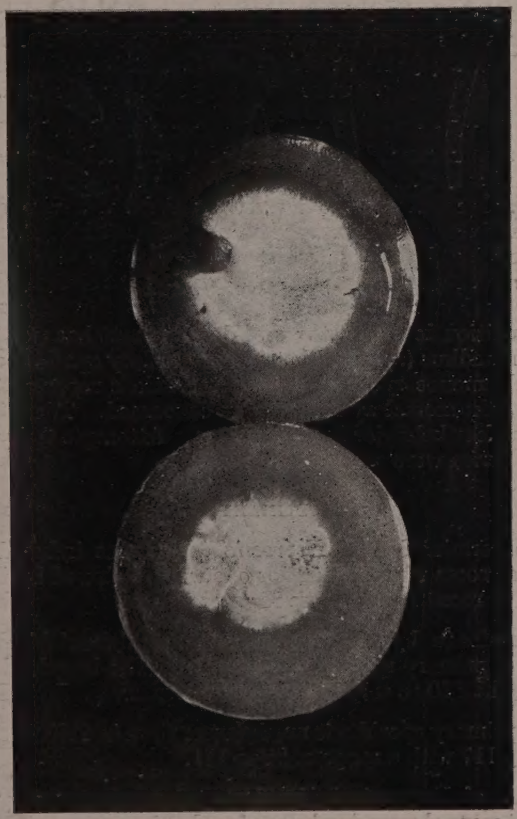

Fig. 2. Sectoring in cultures of *N. indica*

NUCLEAR BEHAVIOUR

The nuclear condition in the primary and secondary sporidia (Figure 3) was determined by staining with iron-alum-hæmatoxylin. Both binucleate and uninucleate primary sporidia were observed, the binucleate condition predominating. The secondary sporidia were found to be primarily uninucleate, only an occasional one being binucleate. At least one secondary sporidium with three nuclei was observed. There was a notable difference in the size of the nuclei in the secondary sporidia of two monosporidial lines (Figure 3). The secondary sporidia of these two lines also differed in size and shape, those containing the smaller nuclei being more elongate than those with the larger nuclei.

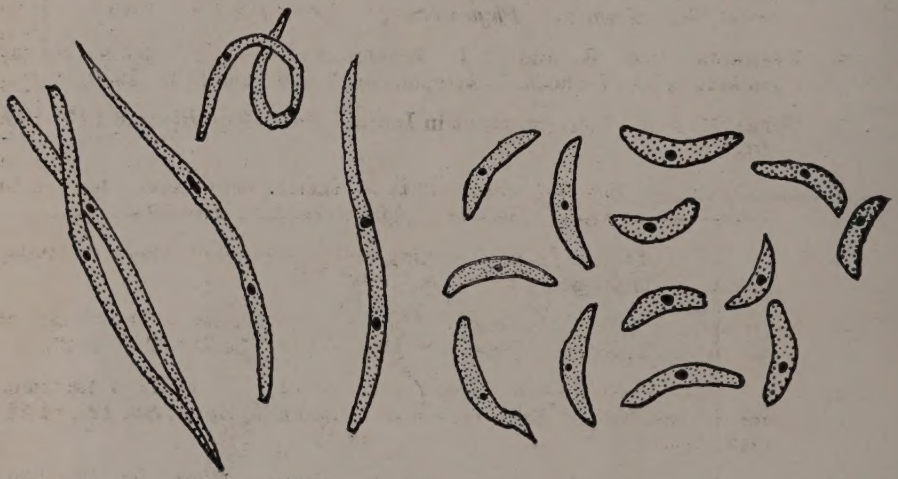

Fig. 3. Sporidia of *N. indica*

The nuclear condition in other stages of development has not been determined. Ramamoorthy and Mundkur (9) state that "the secondary sporidia and the mycelium appear to be entirely monocaryotic." The observations reported here confirm this statement in so far as the secondary sporidia are concerned. There is need for further elucidation of the nuclear behavior in this species. Attempts to hybridize *Neovossia indica* with *Tilletia caries* were unsuccessful.

SUMMARY

Chlamydospore germination in *Neovossia indica* was induced by soaking the spores in tap water at room temperature for one week, followed by incubation on two per cent water agar at room temperature for seven days.

The spores germinate by the production of unbranched promycelia which bear large numbers of primary sporidia at the apex. The length of the promycelium may range from less than 10 to several hundred microns.

The number of primary sporidia is much larger than in *Tilletia caries*, the average of seven spores being 117 with a range of 26 to 171.

Primary sporidia of *Neovossia indica* do not fuse, except very rarely. Among several hundred that were observed only one fused pair was seen.

At least 8 distinct culture types were distinguished among 90 monosporidial lines orignating from one promycelium. Sectors occurred in some of the monosporidial lines, indicating mutation for culture characters.

The majority of primary sporidia observed were binucleate, the remainder being uninucleate. The secondary sporidia were mostly uninucleate, only an occasional one having 2 and 3 nuclei.

Attempts to hybridize *Neovossia indica* and *Tilletia caries* were unsuccessful.

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INFECTIVITY AND LONGEVITY OF DRIED CULTURES OF ASCOCHYTA RABIEI (PASS.) LAB., THE CAUSAL FUNGUS OF GRAM BLIGHT

BY KISHAN SINGH BEDI

(Accepted for publication, January 23, 1949)

DURING the investigations on the blight of gram (*Cicer arietinum*) caused by *Ascochyta rabiei* considerable difficulty was experienced in bringing about infection in hundreds of varieties and crosses for testing their resistance to the disease, due to the want of sufficient inoculum. The usual methods of infecting plants were not found to be feasible. The writer sprayed the plants with spore suspension and then covered them with bell-jars or glass chambers or thick screens made of 'sarkanda' (*Saccharum spontaneum* L.) to maintain high humidity around the plants. But this method had its limitations in that it was not feasible for field-scale trials. The other method that was used was to spread the debris of blight-affected gram plants that had been finely chopped. In this case, however, the tests had often to be deferred until fresh blight-affected material became available. Due to the vagaries of the season, it was not always possible to get enough of such material for starting the experiments at the r ght time. The viability of the spores of the previous year's debris could not alwaiys be relied upon because their germination gradually declined to a considerable extent, during the intervening summer.

The writer, therefore, conceived the idea of using dried cultures of the fungus for bringing about the disease in varieties of gram, so that a constant and steady supply of the inoculum would always be available. The idea suggested itself by the fact that when dried parts of gram, with lesions carrying pycnidia, are brought into contact with the healthy gram plants, they initiate infection if proper conditions of moisture and temperature are provided. It was thought that the fungus, developing on the agar medium, produces a net-work of mycelium, pycnidia and pycnospores similar to those occurring in nature on the diseased plant tissue. This idea led, therefore, to the experiments described below, which consist of drying the cultures of the fungus and using those cultures as inoculum instead of the dried blighted gram plant debris.

THE METHOD OF DRYING CULTURES AND USING THEM FOR INOCULATING GRAM PLANTS

The fungus was cultured in December, 1937, on oatmeal, gram-leaf extract and nutrient glucose agars on which media it formed pycnidia and pycnospores in abundance. On January 1, 1938, the fully-developed fungal colonies were taken out of the culture dishes along with the disc of the medium with a sterile scalpel and placed between sterile sheets of blotting paper. The culture mats were transferred after a few hours to new sheets of sterile blotting paper and kept exposed at room temperature for a couple of days to dry them thoroughly. Alternatively, they were also dried over calcium chloride in desiccators. Several hundred cultures were thus dried for experimental purposes.

One hundred such dried cultures were strung with twine and were suspended on January 15, 1938, just above the gram plants growing in a plot at the Agricultural Farm, Campbellpur. The plants in the plot had been protected against secondary infection by erecting on all the four sides thick '*sarkanda*' (*Saccharum spontaneum*) barriers about 6 to 7 feet in height. As the plot was open from above, there was full play of light and air on the plants growing in the enclosure. An un-inoculated plot screened likewise was also kept to serve as a control. The remaining stock of cultures dried on January 1, 1938, was kept at room temperature

in the laboratory at Campbellpur. Soon afterwards there occurred a good shower of rain and within a week thereafter all the gram plants, over which dried culture mats had been hung, became so severely infected that they were scorched and killed out-right. The uninoculated gram plants in the adjacent enclosed plot remained, however, healthy. This experiment, thus, showed that the virulence of the blight fungus was not impaired by drying its cultures which can be most effectively used for artificially inoculating gram plants. Germination of the pycnospores taken from the dried cultures also did not reveal any deterioration in their viability.

INOCULATION OF GRAM PLANT WITH DRIED CULTURES OF DIFFERENT AGES

It was further deemed necessary to ascertain how long the dried cultures would maintain their infective power. For this purpose, healthy screened plots of gram were inoculated on February 15, March 15 and 31, 1938, and again on March 1, 1939, with cultures dried on January 1, 1938, which had been stored in the laboratory at room temperature. Un-inoculated screened plots were each time kept to serve as controls. The results of these inoculation experiments are presented in Table I.

TABLE I

Results of inoculation tests with dried Ascochyta rabiei *cultures of different ages*

Age of dried cultures	Percentage mortality	Intensity of infection
1½ months	100	Severe
2½ months	100	Severe
3 months	100	Severe
14 months	100	Severe

The four corresponding un-inoculated control plots remained altogether healthy. Thus the infectivity and viability of the 14-month old dried cultures of *Ascochyta rabiei* have been established by these inoculation tests.

VIABILITY TESTS OF DRIED CULTURES

Simultaneously with field trials, laboratory tests of viability of the fungus in the dried cultures of January 1, 1938, were carried out every month. Small bits of dried culture mats were transferred to slants of agar medium after surface sterilisation with mercuric chloride. The dried cultures continued to give rise to pure colonies of *Ascochyta rabiei* upto September, 1940, *i.e.*, for 33 months; thereafter repeated attempts failed to reveal any sign of life in them. Pycnospores failed to germinate and the bits of dried cultures no longer developed into colonies on agar medium.

DISCUSSION OF RESULTS

That the cultures of *Ascochyta rabiei* dried according to the method described in this paper remain viable for a period of 33 months, is very remarkable in view of the fact that ordinarily its cultures in test tubes, petri dishes and other receptacles do not survive the laboratory temperature during summer months in the Punjab plains even for 10 days. It is significant to note here that the longevity of this fungus in dried cultures approximates that of the dry plant debris which is about 3 years as shown by Luthra, Sattar and Bedi (1935). The use of dried cultures of the

blight fungus in infection experiments eliminates all the limitations accompanying the methods of inoculation by the use of spore suspension or the blighted debris. As the gram plants over which dried cultures are hung do not require the artificial provision of humidity around them, the use of bell-jars, glass chambers, or screens to cover the inoculated plants, involving much expenditure in large-scale infections tests, is dispensed with. As a matter of fact, after the cultures have been hung over the plants with twine, no after-care is necessary. In the wake of rain, at any time during the gram season, the spores from the pycnidia are liberated in multitudes and induce severe infection. The dried cultures in consequence of their remarkable longevity provide a constant source of viable and virulent inoculum throughout the gram season whenever there is rain. It may be emphasized that the hanging of dried cultures over the plants more than once during the entire gram season is not also necessary.

Furthermore, as the inoculation by the use of dried cultures does not necessitate the confinement of plants under covers, infection takes place under the natural conditions of light and aeration.

The dried cultures further offer the advantage that particular strain or strains for inoculation purposes can be used. In the case of blighted debris, nothing is known about the number and identity of the strains present therein.

Whereas the blighted debris is not uniformly infective, a high degree of uniformity in inoculation is attainable by the use of dried cultures. All the culture mats required for a particular infection experiment can be obtained by culturing the fungus on any one suitable medium on which it sporulates well. The size of the dried culture mats may even be equalized, but such a precision may be superfluous in view of the fact that there are countless spores in a single culture mat. What is important is that the culture mats should hang about 6 inches above the central shoot of the plant and this height should be maintained by reducing the length of the strings used to hang them as the plants grow taller. The culture mats are kept well above the plants with a view to allowing them to move freely in all directions during rain and thus causing generalized infection over all the plant parts. If this point is not attended to, the culture mats which in the young stage of the plants were well above them, will be concealed among their branches subsequently. Their chance to cause infection will be very much restricted in such cases. By observing these points infection uniform enough for all practical purposes can be secured. The culture mats can be prepared in any quantity and whenever required. Unlike the blighted debris, which may or may not be always available in sufficient quantities in nature, the supply of culture mats is always assured.

For maintaining the viability of fungi and bacteria, it is necessary to subculture them frequently and to keep them at a suitable temperature especially in hot climates. Despite much care, the cultures are liable to be contaminated by mites and other undesirable organisms. The development of saltant strains and other abnormal growths is not uncommon during the course of prolonged culturing and the maintenance of the cultures in a pure and unchanged state is a matter of considerable difficulty. To obliviate these disadvantages, attempts have been made by investigators to store cultures of fungi and bacteria by different methods. Spores have been preserved for long periods mixed with earth, chopped straw, chalk or sand. Thaysen (1924) described a method of storage of bacteria on sand in sealed tubes and in a later paper (1934) he recorded further data on the viability of both bacteria and fungi preserved by this method. He claims to have kept the spores of

Rhizopus japonicus viable for 12 years. Galloway (1936) also published the results of his experiments on the preservation of some fungi on sand in sealed tubes. The method of preservation is rather elaborate and needs considerable labour and skill. Furthermore, sand cultures in sealed test tubes are successful in maintaining the viability of fungi for long periods in cold climate but in the plains of India their utility diminishes considerably.

By the method of drying cultures described in this paper the necessity for subculturing the gram blight fungus at frequent intervals and keeping it in cool incubators or refrigerators during summer is dispensed with. The danger of contamination by mites, bacteria and other fungi is eliminated and the fungus can be maintained in an unchanged state, free from admixture with other strains. Furthermore, the method of drying the cultures is very simple. When it is desired to reculture the fungus, only small bits of the dried mats are transferred to slants or plates of agar medium. Within a few days pure colonies of the fungus are obtained.

In order to ascertain whether the drying of cultures of other fungi for prolonging their life is also possible, cultures of *Rhizoctonia bataticola*, *Colletotrichum falcatum*, *Colletotrichum graminicolum*, *Colletotrichum gloeosporioides*, *Alternaria solani* and *Ascochyta pisi* were dried. It was gratifying to find that all the fungi were viable at the end of one year, after which, due to certain reasons, the viability tests could not be continued. It is hoped to take up the work again and to include a much larger range of fungi, both parasitic and saprophytic. The infectivity of the dried cultures of parasitic fungi among them will also be tested and the results will be reported in a separate communication.

SUMMARY

1. Ordinarily the cultures of *Ascochyta rabiei*, the causal fungus of the blight disease of gram, in test tubes, dishes and other receptacles cannot survive the laboratory temperatures during summer months in the Punjab plains even for 10 days. A method has been devised by which the culture mats are generally dried and kept in an unchanged, uncontaminated and viable state for very long periods (33 months under the conditions of the experiment).

2. The dried cultures maintain their infectivity in an unimpaired state for long periods and can be successfully and very easily used to infect gram plants. The method of using them for purposes of infection is described.

3. The use of dried culture in connection with resistance tests of gram varieties eliminates many difficulties experienced in field-scale inoculations.

ACKNOWLEDGMENTS

I wish to express my thanks to Mr Jai Chand Luthra and Dr A Sattar, both of the Punjab Agricultural College, Lyallpur, for the encouragement they gave me during the course of this investigation. I am also indebted to Dr B. B. Mundkur, Deputy Director, Directorate of Plant Protection, Quarantine and Storage, Ministry of Agriculture, Government of India, for his kindness in going through the manuscript and for making many valuable suggestions.

Department of Agriculture
East Punjab, Ferozepur

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A CONTRIBUTION TO THE FUNGOUS FLORA OF PAKISTAN AND INDIA

BY SULTAN AHMAD

(Accepted for publication, January 28, 1949)

1. **Thyridaria incrustans** Sacc.
   On dead branches of **Salvadora oleoides,** Rohtak, no. 1009

2. **Ascobolus glaber** Pers. ex Fr.
   On rabbit dung, Rohtak, June 1943, no. 808

3. **Lamprospora constellatio** (B. Br.) Seaver (Brown form)
   On the ground, Rohtak, July 21, 1942, no. 852

4. **Humaria pulcherrima** (Crouan) Speg.
   On cow dung, Rohtak, January 21, 1945, no. 1821

5. **Schizoxylon insigne** (de Not.) Rehm
   Syn. *Oomyces insignis* de Not.
   Schizoxylon alboatrum Rehm
   S. occidentalis Ell. & Ev.
   On dead branches of **Punica granatum,** Ladhar, Sheikhupura, Nov. 28, 1947, no. 2220 Rohtak

6. **Geoglossum velutipes** Peck
   On the ground in an oak forest, Murree, August 1948

7. **Leottia lubrica** (Scop.) Pers.
   Syn. *L. gelatinosa* Hill
   On the ground in an oak forest, Murree, August 1948

9. **Helvella ephippium** Lév.
   On the ground, Murree, August 1948, no. 2527. A very common species differing from all the closely allied species in its decidedly villose under surface of the pileus and stipe.

10 **Helvella fusca** Gill.
   On the ground, Murree, August 1948, no. 2528

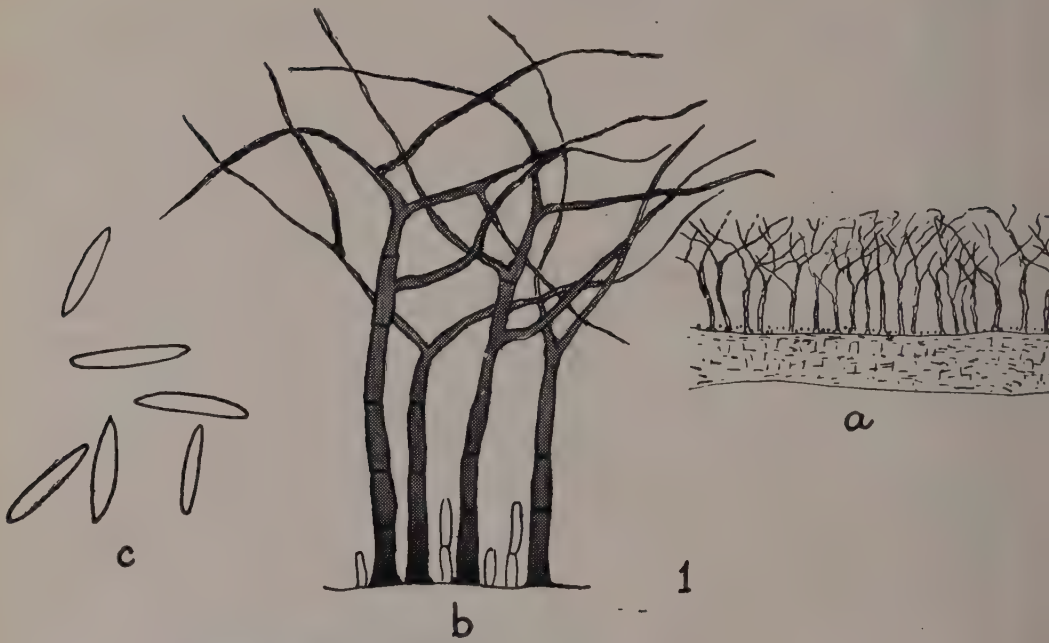
11. **Hypocrea citrina** (Pers.) Winter
    On dead branches and covering large portions of a rock, Murree, August 1948, no. 2523

12. **Glonium lineare** (Fr.) de Not.
    On dead wood, Murree, August 1948, no. 2406

13. **Stictis radiata** (L.) Pers.
    On dead branches of **Sarcococca pruniformis,** Murree, August 1948

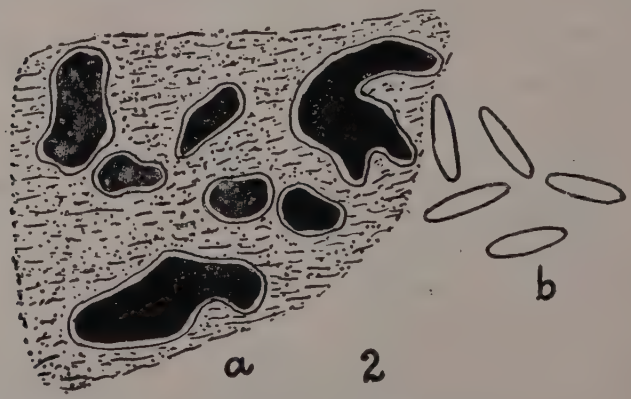
14. **Clavaria pistillaris** L.
    On the ground, Murree, August 1948, no. 2536

15. **Hendersonia obtusa** Cke.
    Syn. *H. lonicerae* Cke. (nec Fr.)
    On dead branches of **Jasminum sambac,** Ladhar, Sheikhupura, July 14, 1947, no. 1910. This species was originally described from Saharanpur, India, on twigs of *Lonicera diversifolia.*



16. **Circinotrichum maculiforme** Nees (Fig. 1, a-c)
Superficial, spreading over the surface, velvety, mouse-gray to dark mouse gray. Sterile hyphæ erect, septate, smooth, 140-148μ long, 3.7-4.5μ thick, mouse-gray at the base, paler above and hyaline at the apex, dichotomously branched, branches tapering, hyaline, flexuose, entangled to form a palisade like layer ; conidia bearing hyphæ short, hyaline, cylindric clavate, unseptate, 10-12μ long, 2-2.5μ thick ; conidia acrogenous, cylindric-fusiform, at times somewhat curved, hyaline, 1-celled, 1.75-2 x 10-13.5μ.

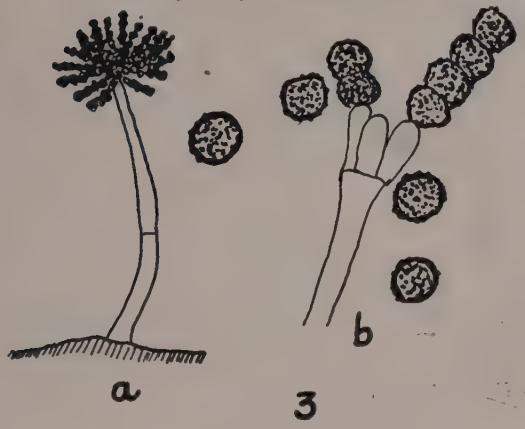
On fallen leaves of **Cordia obliqua** Willd., Bot. Gard., Lahore, March 21, 1948, S. Ahmad, no. 2278



17. **Myrothecium roridum** Tode ex Fr. (Fig. 2, a-b)

Sporodochia superficial, sessile, circular or irregular, often confluent, olivaceous when fresh, becoming black on drying, surrounded by a conspicuous halo of white mycelium; conidiophores erect, branched, hyaline, septate, forming a palisade-like layer. Conidia hyaline, 1-celled, cylindric, 1.5-2 x 6.6-7.5μ.

On dead branches, leaves and bark of trees, Ladhar, Sheikhupura. September 25, 1947, S. Ahmad, no. 2146; Rohtak. Very common



18. **Memnoniella echinata** (Riv.) Galloway (Fig. 3, a-b)

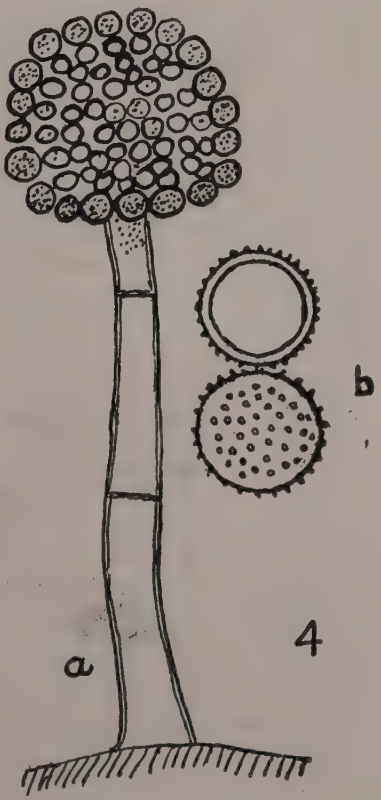
Conidiophores in clusters, unbranched, septate, black, 4.5-5 x 50-60μ; bearing a terminal group of 3-8 sterigmata; sterigmata light coloured, 3 x 9.3μ; conidia catenate, black (opaque), globose, verrucose, 4.5-6μ in diameter.

On dead branches, leaves, etc. of different plants, Lahore, March 21, 1948, S. Ahmad, no. 2281; Ladhar, Sheikhupura, Sep. 15, 1947, no. 2145

19. **Periconia pycnospora** Fres. (Fig. 4, a-b)

Sterile hyphæ invisible; conidiophores scattered, erect, unbranched, septate, brown, 136μ long and 10.2-13.6μ in diameter; head globose; conidia connected in easily separable chains, globose, brownish, verrucose, 12.5-15.5μ in diameter.

On a dead branch, Lahore.



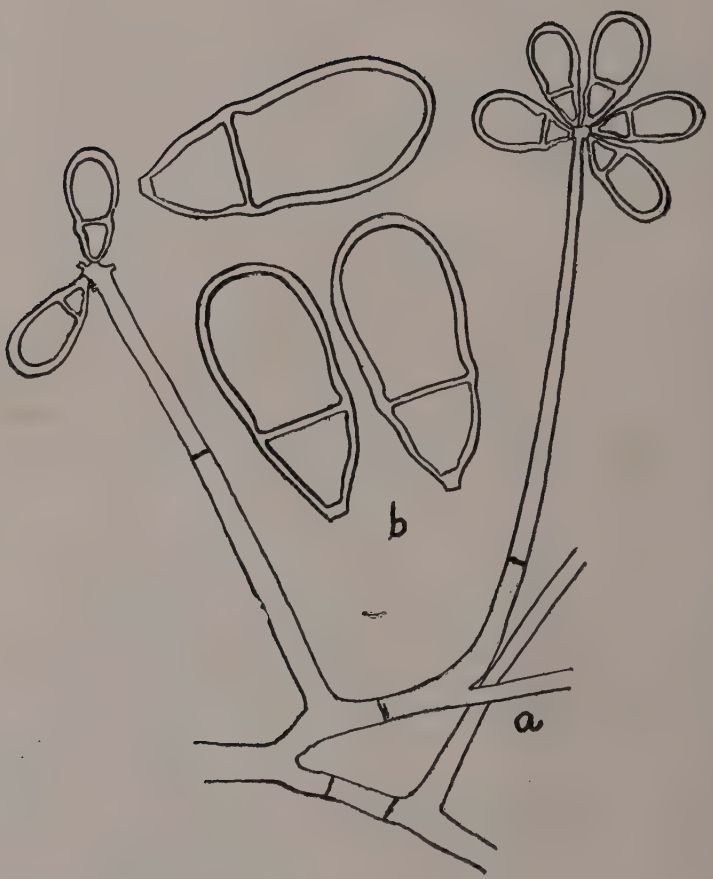
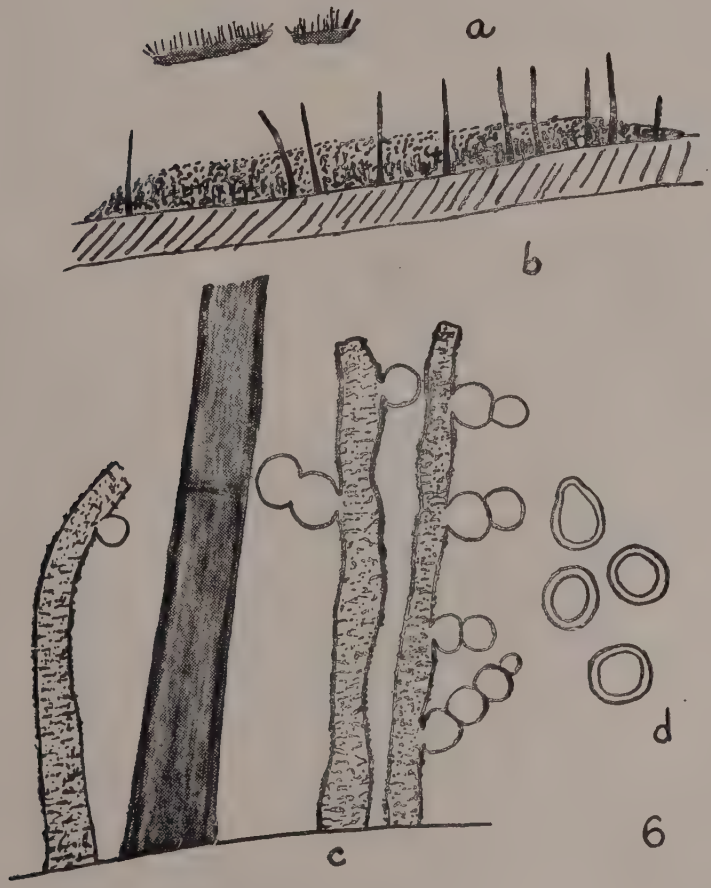


Fig. 5.

20. **Trichothecium inæquale** Mass. & Salm. (Fig. 5, a-b)

Mycelium white, branched, septate; conidiophores erect; conidia acrogenous, 4-8 on a conidiophore, obovate to sub-pyriform, 2-celled, the lower cell much smaller than the upper, attenuate towards the base, constricted in the middle, hyaline, 28-34 x 10.8-15.9μ.

On horse dung and on decaying branches of a small herb, Lahore; February, 15, 1948



21. **Lacellina libyca** Sacc. & Trott. (Fig. 6, a-d)

Superficial, black setose masses, solitary or confluent, covering large areas; setæ rigid, pointed, dark brown, interspersed through out; conidiophores simple, yellowish brown, flexuose, torulose, muriculate, 3.5-5 x 50-60μ; conidia globose, sub-globose or irregular, dark brown, verrucose, 5-7.5μ in diameter.

On dead culms and leaves of Gramineæ, esp. **Saccharum munja** and **S. spontaneum,** Lahore; Ladhar, Sheikhupura; Rohtak. Very common.

Botany Department
Government College, Lahore, Pakistan

EXPLANATION OF TEXT FIGURES

Figure **1. Circinotrichum maculiforme**

a. Vertical section showing the habit x 150
b. A portion magnified x 550
c. Conidia x 1200

2. Myrothecium roridum

a. Habit x 30
b. Spores x 1800

3. Memnoniella echinatum

a. A single conidiophore x 550
b. A portion magnified x 1200

4. Periconia pycnospora

a. Habit sketch x 550
b. Spores x 1200

5. Trichothecium inæquale

a. A portion showing the conidiophores and conidia x 550
b. Conidia x 1200

6. Lacellina lybica

a. Habit x 10
b. Vertical section showing setæ x 150
c. Conidiophores and portion of a seta x 1200
d. Conidia x 1200

CHACONIA TECTONAE RAMAKRISHNAN T. S. & K. SP. NOV. ON TEAK

BY T. S. RAMAKRISHNAN AND K. RAMAKRISHNAN

(Accepted for publication, January 28, 1949)

TEAK trees, *Tectona grandis* L., in the forests of Malabar and Coimbatore are usually attacked by a rust during the months of October to February. Only the leaves are affected, the lower surfaces of which present a bright yellow to orange colour due to the formation of numerous sori. The sori are minute and a careful examination reveals that they are mostly uredia and telia. The upper surface of the leaves may present a grey appearance due to the formation of flecks which correspond to the position of the sori below.

Uredia are minute, 0.2 to 0.5 mm. in diameter and powdery in appearance. They are formed subepidermally on compact stromata but they soon burst through the epidermis and become exposed. Surrounding each sorus are numerous stout, incurved paraphyses and the spores are held in the hollow thus formed. When scrapings are made, the entire sorus together with the paraphyses comes off as a mass. The urediospores are globose to oval, with colourless and echinulate walls and yellowish contents.

Telia are mixed with the uredia, orange coloured and waxy. They develop subepidermaly but very soon burst through the epidermis and project beyond the surface. Each telium has many paraphyses along the periphery. These paraphyses bend inwards and resemble those formed around the uredia. The teliospores are sessile, cylindric–clavate to fusiform, with a hyaline wall and orange-yellow contents. They are produced in clusters from basal cells formed on a compact stroma. The basal cells are not easily separated. Germination takes place *in situ* and the promycelium is formed by the apical prolongation of the spore-apex. A septum is evident in old promycelia, at the junction with the spore or a little above. The promycelium is stout, short, often bent, and four-celled. An elliptic or round basidiospore is produced on each cell on a well developed sterigma. After germination the spore collapses. Uredia and telia rapidly lose their colour in storage. They become almost whitish a month after collection and the spores themselves are almost subhyaline to hyaline

A rust on teak was described by Raciborski (1900) but he did not find the telial stage and therefore named it *Uredo tectonae*. The same rust has been recorded from Mysore and several places in Northern India by Butler and Bisby (1931). The description of *Uredo tectonae* and the measurements of its urediospores agree with those of the rust under study. Raciborski (1900) did not notice any paraphyses but Koorders (1907) observed them in material collected by him in Java. The type specimen of *Uredo tectonae* was unfortunately not available but a fragment of a specimen collected and determined by Butler as *Uredo tectonae*, was kindly made available to us from the *Herb. Crypt Ind. Orient.* of the Indian Agricultural Research Institute,

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[Since sending this to the press Dr. M. J. Thirumalachar has collected and described this rust from Bangalore and named it *Olivea tectonae* (*Curr. Sci.* **18**: 175, 1949). We are of opinion, however, that the rust must be placed in the genus *Chaconia* only, in spite of the presence of paraphyses because of the mode of development of the sori. *Olivea* has subcuticular telia and uredia and the paraphyses form a nest like appearance. Neither of these characteristics are exhibited by the rust under study. If it is argued that the uredia and telia of *Olivea* are really subepidermal and not subcuticular as stated by Arthur, the author of the genus, then the difference between the two genera boils down to the presence or absence of paraphyses. This character cannot be used for generic differentiation since in many genera of rusts considerable variation is observed in the presence or absence or the mode of development of paraphyses. Hence the older of the two genera (*Chaconia*) has priority. T. S. R. & K. R.]

New Delhi. Uredia in this specimen are surrounded by incurved paraphyses and the measurements of the urediospores show complete agreement with those of our collections. There is little doubt that the two rusts are identical.

The specimens collected by us have telia, unobserved by the previous investigators. Both the uredia and telia have a general resemblance to *Chaconia* and *Olivea*. As in the species belonging to the former genus, uredia and telia are subepidermal but the sori are surrounded by paraphyses as in *Olivea*, a feature not found in *Chaconia*. As the presence or absence of paraphyses in the sori is not a characteristic of much diagnostic value, the rust is assigned to the genus *Chaconia*. As in *Chaconia*, the uredia and telia are subepidermal, a morphological feature to which much importance is attached in the separation of the genera of rusts (Mains, 1939). These sori are subcuticular in *Olivea*. The rust is named *Chaconia tectonae*.

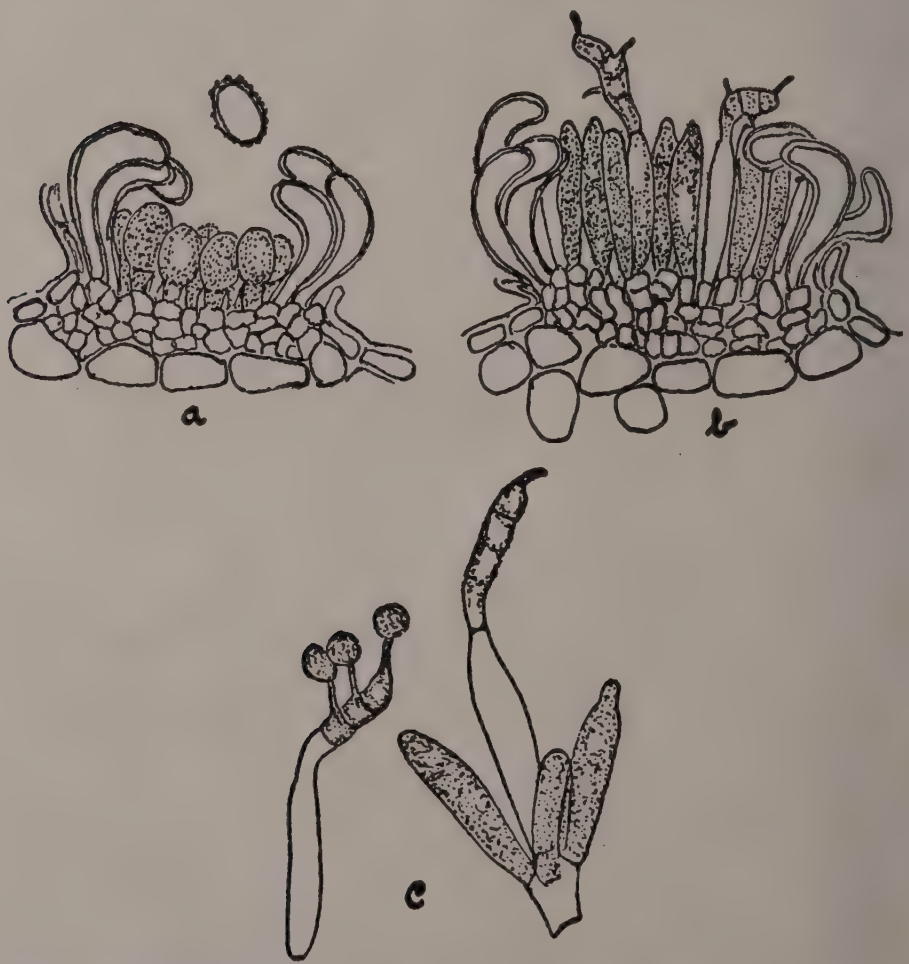

Fig. (a) Section of uredium ; (b) Section through telium (c) Acluster of teliospores (x 500)

Chaconia tectonæ Ramakrishnan T. S. and K. *sp. nov.* (Fig. 1, a, b, c).
Syn. Uredo tectonae Raciborski in *Parasitische Algen und Pilze Java's*, **1** : 28, 1900

Pycnia and æcia unknown. Uredia hypophyllous, subepidermal, erumpent, bright yellowish-orange, powdery, paraphysate ; paraphyses subhyaline, incurved, non-septate, surrounding the sorus at the periphery ; urediospores subglobose or oval, yellowish-orange, echinulate, 23 x 18μ (18-28 x 14-22μ) with hyaline wall and short pedicel. Germ-pores obscure. Telia hypophyllous, mixed with uredia, waxy, subepidermal, erumpent, orange coloured, paraphysate as in uredia ; teliospores one-celled, cylindric-clavate or fusiform, with yellowish orange contents, 32 x 7μ (22-40 x 4-11μ), thin walled ; formed in groups from basal cells, sessile ; germinating *in situ*, promycelium short, 4-celled ; basidiospores round or elliptic.

On living leaves of *Tectona grandis* L. October 13, 1948, Walayar (Malabar, Madras Prov.), leg. T. S. Ramakrishnan and K. Ramakrishnan. Type deposited in the Herbarium of the Mycology Section, Agricultural Research Institute, Coimbatore.

Pycniis aeciisque non cognitis. Urediis hypophyllis, subepidermalibus erumpentibus, flavo-luteo colore, pulverulentis, paraphysatis ; paraphysibus subhyalinis incurvatis, nonseptatis, ad oram sori orientibus ; urediosporis subglobosis, ovalibus, echinulatis, flavoluteo colore, breviter pedicellatis, 23 x 18μ (18-28 x 14-22μ), parieto hyalino, germanation is foraminibus obscuris. Teliis hypophyllis urediis commixtis, cereis, luteis, subepidermalibus, erumpentibus, ut in urediis paraphysatis ; teliosporis unicellularibus, sessilibus cylindricis-clavatis, vel fusiformaibus, pariete tenui, flavis luteis contentis, 32 x 7μ (22-40 x 4-11μ), catervatim ob imis cellulis orientibus, in situ germianti ; basidiis brevibus, 4 cellulatis ; basidiosporis orbicularibus vel ellipticis.

In vivis foliis *Tectonae grandis* L. Walayar, Malabar, 13-x-1948, leg. T. S. Ramakrishnan et K. Ramakrishnan.

We are grateful to Rev. Fr A. Rapinat of the Loyola College, Madras, for kindly rendering the diagnosis into Latin and to Dr G. R. Bisby of the Commonwealth Mycological Institute, Kew, England, for going through the manuscript of this paper and offering critical remarks.

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TRANSMISSION OF WHEAT BUNT DUE TO NEOVOSSIA INDICA (MITRA) MUNDKUR

BY S. KISHAN SINGH BEDI, M. R. SIKKA AND B. B. MUNDKUR

(Accepted for publication, February 10, 1949)

A bunt of wheat known as "new bunt" or "Karnal bunt", which it is now proposed to rename as "partial bunt", causes substantial losses to the wheat crop in several parts of East Punjab. It is especially serious in those districts where a humid climate prevails during the latter part of the wheat growing season but in a mild form the disease is present in the other districts also and in Delhi and the western districts of the United Provinces. In West Punjab and the North Western Frontier Province of Pakistan, the disease is known to cause much damage.

The symptoms produced by this bunt, unlike those caused by the bunts due to *Tilletia caries* (DC.) Tul. or *Tilletia foetida* (Wallr.) Liro, are entirely different. In those two bunts, all the ears in a stool are attacked but in partial bunt all the ears are not attacked and in an affected ear only a few grains, not more than five or six, are turned into sori. These sori are not regularly arranged in the ear nor do they occur on any particular side, but they are very irregularly distributed. Whereas in the other two bunts the entire grain is turned into a bunt-ball, in this bunt only two or three grains in the ear are so transformed, the remaining being only partially attacked. As the partially attacked grains are more numerous, the name "partial bunt" seems very appropriate. The general appearance of a bunted ear gives the impression that it is not a systemic disease.

The mode of transmission of this disease had, until recently, remained obscure. Thinking that it might be seed-borne like the other bunts, Mundkur (1943) laid down a series of experiments to induce the disease but obtained uniformly negative results. Later he (1943) reported that he had succeeded in inducing partial bunt in his experimental plants both at Delhi and at Simla by infecting the floral parts of the plants at the time of anthesis with the sporidia of the fungus. In order to gather additional evidence on the mode of transmission of this bunt, work was laid out at Lyallpur and had been carried out for several years. As the records of those tests are with the Plant Pathologist at Lyallpur which is now in Pakistan, experiments were again laid out in Gurdaspur, Gumar and Kangra during the wheat season of 1947-1948. These experiments, confirm the findings obtained in previous years by the United Punjab Agricultural Department and are reported in this paper.

There are three possible ways in which partial bunt may perpetuate from year to year. They are :

1. Infection from the soil.
2. Infection through the seed.
3. Infection through the floral parts.

Tests were laid out to see if the disease could be perpetuated from year to year by any one of these means.

ARTIFICIAL SOIL INFECTION TESTS

Small plots, each 25 square feet in area, were heavily infected with viable spores of *Neovossia indica* during the latter part of summer of 1947 at Gurdaspur. Similar plots but without infection were kept as controls. The seed (variety C591) to be sown in these plots was subjected to the standard hot water treatment to ensure freedom from bunt infection. Sowing was done on 15th, 20th and 26th of November and again on 2nd December, 1947. When flowering was about to start and the ears were still enclosed in the boot-leaf, 10 ears in each plot were enclosed in paper bags

to exclude any chance of infection. At the time of harvest, the ears were carefully collected and the incidence of bunt was calculated. The results are recorded in Table I.

TABLE I

Incidence of 'partial bunt' in infected and control plots

Sowing date	Artificially infected plot		Control plot	
	Ears open to infection %	Ears bagged %	Ears open to infection %	Ears bagged %
Nov. 15th ..	35	0	26	0
Nov. 20th ..	12	0	55	0
Nov. 26th ..	32	0	2	0
Dec. 2nd ..	15	0	30	0

An examination of the data recorded above indicates that bunt develops both in plots artificially infected with bunt spores and in control plots. Its total absence in ears that had been enclosed in paper bags proves that it is not soil-borne or systemic.

ARTIFICIAL SEED INFECTION TESTS

Seeds of variety C 591 were again subjected to the hot water treatment to ensure freedom from bunt infection ; they were then divided into four lots as follows :—

I Seeds smeared with dry spores.
II Seeds smeared with spores soaked for several days in water.
III Seeds germinated in the laboratory and smeared with sporidia.
IV Untreated seed to serve as controls.

A fifth lot of seed consisted of typically bunted grains of the same variety ; the embryos were intact but the endosperm had been turned into bunt-balls.

The seed was sown in plots, each 25 square feet in area, at Gurdaspur on December 2, 1947. Ten ears in each plot were enclosed in paper bags before they had emerged out of the boot leaves. Incidence of bunt was ascertained after the ears had been harvested ; the results are recorded in Table II.

TABLE II

Incidence of 'partial bunt' in a crop raised from artificially and naturally infected seed

Serial No.	Treatment	Ears exposed to natural infection %	Ears bagged %
1.	Healthy seed smeared with dry spores	13	0
2.	Healthy seed smeared with pre-soaked spores ..	16	0
3.	Seedlings smeared with sporidia	10	0
4.	Bunted but viable seed	12	0
5.	Control	15	0

It will be noted from the data recorded in Table II that infection occurs in all the ears that had not been bagged, irrespective of whether the seed was healthy or

diseased, smeared with spores or with sporidia. When the ears were bagged infection did not take place, providing further proof that partial bunt is not seed–or soil-borne, or systemic.

FLORAL INFECTION TESTS

Experiments to prove that this bunt is air-borne and that infection takes place at the time of anthesis of the flowers were undertaken in March 1948 at the Agricultural Experiment Station at Gurdaspur. Four varieties of wheat were selected for the experiment and when the ears were in the boot stage, they were bagged to prevent any possible aerial infection. A large number of spores were then germinated and sporidia were kept ready for conducting the tests. When anthesis started, a large number of ears that had been bagged were infected with the sporidia using the vacuum method devised by Moore (1936) and again enclosed in bags. An equal number of bagged ears was kept as controls. The ears were harvested and the incidence of bunt is recorded in Table III.

TABLE III

Results of floral infection of wheat with sporidia

Serial No.	Variety	Per cent infection	
		inoculated	not inoculated
1.	C 591	100	0
2.	C 228	50	0
3.	I.P. 165	33	0
4.	Punjab T7	50	0

The data recorded in Table III prove that artificial infection of wheat flowers with sporidia, obtained from germinating spores of *Neovossia indica*, can bring about the disease. Typically bunted grains, some of which were completely affected, have been obtained in these experiments. Ears that had been bagged but were not infected did not, however, show bunt infection.

It should be pointed out that there was abundant rain and relatively low temperature during the first week of March when the flowers were inoculated with the sporidia. In previous years, it had been observed that unless such wet conditions prevailed, successful inoculations were difficult to obtain.

In the case of partial-bunt, floral infection leads to the immediate transformation of the ovaries into bunt-balls. Such bunt-balls may entirely destroy the grains or they may be partially destroyed. Whereas in bunts due to *Tilletia caries* and *Tilletia foetida* all the grains in the ear are destroyed, in this bunt only a few grains are totally damaged. The loss caused, therefore, is not very great but due to the foetid odour which the partially attacked grains impart, such wheat becomes unsaleable.

The question of controlling this bunt is of much importance. As the other two bunts are externally seed-borne, they have been effectively controlled by seed treatment. In the case of partial bunt, however, the use of resistant varieties obtained either by selection from among already existing varieties or by hybridization, appears to be the only effective method of its control.

REACTION OF SOME WHEAT VARIETIES TO PARTIAL BUNT

A tentative trial to determine the relative resistance of some of the important wheat varieties that were being grown at Gurdaspur, Gumar and Kangra farms was also conducted during 1948. There were in all 54 varieties and these were infected with sporidia obtained by germinating the spores. The results of these tests are given in Table IV.

TABLE IV

Incidence of 'partial bunt' in 54 varieties of wheat

Name of Variety or cross	% infection on ear basis			Name of Variety or cross	% infection on ear basis		
	Gurdaspur Farm	Kangra Farm	Gumar Farm		Gurdaspur Farm	Kangra Farm	Gumar Farm
T. 1 ..	0.0	0.0	0.0	I.P. 52 ..	0.0	100.0	0.0
T. 2 ..	0.0	0.0	0.0	I.P. 80-5	40.0	60.0	40.0
T. 3 ..	0.0	0.0	0.0	I.P. 101 ..	60.0	25.0	0.0
T. 4 ..	25.0	0.0	0.0	I.P. 111 ..	60.0	0.0	0.0
T. 5 ..	60.0	0.0	—	I.P. 114 ..	50.0	25.0	25.0
T. 6 ..	20.0	50.0	—	I.P. 120 ..	40.0	0.0	0.0
T. 7 ..	80.0	0.0	—	I.P. 125 ..	50.0	0.0	0.0
T. 8 ..	0.0	0.0	—	I.P. 165 ..	75.0	50.0	66.6
T. 9 ..	0.0	0.0	—	8 A ..	50.0	0.0	20.0
T. 10 ..	33.3	60.0	0.0	8 B ..	50.0	20.0	25.0
T. 11 ..	40.0	0.0	33.3	9 C ..	25.0	0.0	0.0
T. 12 ..	33.3	0.0	0.0	9 D ..	0.0	0.0	20.0
T. 13 ..	66.6	0.0	—	C 215 ..	25.0	40.0	0.0
T. 14 ..	33.3	0.0	—	C 217 ..	66.6	50.0	25.0
T. 15 ..	0.0	0.0	0.0	C 228 ..	75.0	60.0	33.3
T. 16 ..	33.0	0.0	0.0	C. 230 ..	0.0	0.0	25.0
T. 17 ..	25.0	33.0	0.0	C. 231 ..	50.0	20.0	0.0
T. 18 ..	25.0	20.0	0.0	C 244 ..	20.0	0.0	0.0
T. 19 ..	25.0	0.0	0.0	C 245 ..	25.0	25.0	0.0
T. 20 ..	25.0	0.0	0.0	C 247 ..	40.0	60.0	0.0
T. 21 ..	20.0	0.0	0.0	C. 248 ..	0.0	50.0	0.0
T. 22 ..	0.0	0.0	—	C. 250 ..	50.0	60.0	—
T. 23 ..	20.0	25.0	—	C. 409 ..	25.0	0.0	0.0
T. 24 ..	50.0	40.0	—	C. 499 ..	20.0	40.0	0.0
T. 25 ..	20.0	0.0	—	C. 518 ..	25.0	0.0	0.0
I.P. 4 ..	66.6	25.0	0.0	C. 591 ..	50.0	100.0	25.0
I.P. 12 ..	0.0	0.0	0.0	Nabawa ..	0.0	0.0	50.0

An examination of the data presented in Table IV shows that Punjab types Nos. 1, 2 and 3 which are durums, remain free from bunt infection at all the 3 places, *viz.*, Gurdaspur, Kangra and Gumar. Even under natural conditions of infection they have shown 100 per cent resistance to the disease. Punjab types Nos. 8, 9, 15 and 22 which were not affected in the above experiment were, however, attacked under natural conditions of infection, their escape, therefore, being only accidental. These trials will be repeated again and again to find out if there are any resistant segregates among these varieties.

At the Gurdaspur and the Kangra farms certain yield trials were in progress during 1947-1948 and as conditions for infection of wheat flowers by the partial bunt were good, advantage was taken to note the incidence of bunt in those plots. The results are recorded in Tables V and VI.

TABLE V

Kangra Farm. Incidence of 'partial bunt' under natural conditions

Variety	Bunt incidence on plant basis		Bunt incidence on grain per ear basis	
	Range of infection %	Average %	Range of infection %	Average %
C. 228	26–69	59	2–9	3
9 D	30–78	58	1–4	3
C 261	33–71	48	1–2	1.5
C 250	35–73	55	0.5–6	2
C 260	31–60	49	1.0–3	1.5
I.P. 80-5	29–71	51	0.5–3	2
C 253	39–89	69	1–9	3
C 591	31–81	55	1–6	3

It will be noted from Table V that none of the varieties included in the yield trials at Kangra in 1947-48 were resistant to the disease. Variety C 253 appeared, however, to be the most susceptible to the disease followed by C 228 and C 591 and I.P. 80–5.

TABLE VI

Gurdaspur Farm. Incidence of 'partial bunt' under natural conditions

Variety	Unirrigated area (rain-fed)		Irrigated area	
	Range of infection %	Average %	Range of infection %	Average %
C259	0.4–2.8	1.6	5.1–9.5	7.5
C237	0.4–8.2	3.0	3.0–7.2	5.7
C228	0.2–4.1	2.0	2.7–5.6	3.7
C258	0.2–2.6	1.6	2.8–7.0	4.2
C409	0.8–3.4	1.7	3.8–7.1	4.7
C217	0.9–3.9	2.3	1.7–6.4	3.5
C250	0.6–2.0	1.1	2.0–6.5	4.1
C260	0.4–2.6	1.6	1.8–6.9	3.0
C265	0.6–2.3	1.4	2.6–5.4	3.7

In addition to showing that none of the varieties included in the yield trials are resistant, the data recorded in Table VI indicate that incidence of partial bunt is definitely more in irrigated areas than in non-irrigated areas, possibly because of more abundant humidity. Irrigation water helps the spores of *Neovossia indica* to germinate in abundance and the humidity within the crop eliminates desiccation and, therefore, the death of the sporidia.

DISCUSSION

In the course of the past few years a large number of villages in the Ambala Gurdaspur and Karnal districts have been visited and the incidence of the disease carefully observed. In some villages, such as Shahabad of the Karnal District, infection has varied from a trace to 30 per cent and at Rupar in the Ambala District, from a trace to 22 per cent. In heavily manured, clayey and irrigated, soils where the crop had lodged, the incidence of the disease on the basis of grain attacked has been as high as 30 per cent but in unirrigated fields with little or no manure and where the crop had not lodged, the incidence was less than 2 per cent.

There is little doubt that partial bunt due to *Neovossia indica* is an air-borne disease causing floral infection. The spores of the fungus which lie in the soil germinate at the time of the flowering of the wheat crop, if abundant moisture and cool

temperature are present. The sporidia are wafted in the air and deposited by wind and moisture on the flowers at the time of their pollination. They then germinate and attack the ovary which is thus turned into a bunt sorus. Complete destruction of the ovary is rare, partial destruction being more common.

Abundant rain at the time of anthesis of the wheat flowers, irrigation of the fields and heavy manuring help the spores germinate freely and cause the disease. In March 1946 the rain-fall at Gurdaspur was 0.72 inch ; in March 1947 it was 0.33 inch. During those years, the incidence of partial bunt was negligible. In March 1948, however, the rainfall was 3.61 inches and partial bunt appeared in an epidemic form.

Development of resistant varieties both by selection and hybridization appears to be the only method of controlling partial bunt. Efforts towards that end are being made by the East Punjab Department of Agriculture.

SUMMARY

Partial bunt due to *Neovossia indica* is wide-spread in East Punjab. Experiments, carried out at Gurdaspur to see if it is soil-or seed-borne, have given uniformly negative results.

When the floral parts of the wheat plants were infected with spordia at the time of anthesis, the disease became manifest in the experimental plants without exception, showing that the disease is air-borne and takes place at the time the flowers are being pollinated.

Resistance of 54 varieties of wheat was tested at Gurdaspur, Kangra and Gumar farms and it was found that the three durum wheats, Punjab Types 1, 2 and 3, were completely resistant to the disease. Others showed various degrees of infection.

Under natural conditions, it was noted that the incidence of the disease is heavy in fields that have been irrigated and manured. In fields that have not been irrigated and have received little or no manure, there is less bunt. Observations made over a period of years show that if there is abundant rain in March when the wheat flowers are in the anthesis stages in East Punjab, then the disease appears in an epidemic form.

Agricultural Department
East Punjab
Ferozepur

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THE OCCURRENCE OF PYTHIUM VEXANS DE BARY IN SOUTH INDIA

BY T. S. RAMAKRISHNAN

(Accepted for publication February 15, 1949)

PYTHIUM VEXANS was first described by De Bary as a saprophyte on potato tubers from Germany. Butler (1907) reported that "it is possible that the *Pythium* found by Cunningham in India in 1897 on living potato plants was this species. De Bary failed entirely to cause *Pythium vexans* to attack living potato and this fact makes it a matter of considerable doubt what species Cunningham's really was". However, Butler and Bisby (1931) do not list this species in their Fungi of India. Braun (1924) created *Pythium complectens* which was found to cause a black stem rot of *Coleus* and *Pelargonium* cuttings. He states that his species resembled *Pythium vexans* in some respects but differed in others, and consequently thought it fit to consider it as new. Mathews (1931) has accepted the two fungi as separate species. Middleton (1943) however does not hold the same view and has merged *Pythium complectens*, *Pythium piperinum* Dast., *Pythium allantocladon* Sideris, *Pythium polycladon* Sideris, *Pythium ascophallon* Sideris, and *Pythium euthyhyphon* Sideris into *Pythium vexans* on the basis of close relationship between these species in the characters of the sporangia, oogonia, oospores, growth habits and temperature relationships. That view has been adopted in this communication also, as it appears to be quite justifiable. Middleton has given a list of 36 genera of host plants from which this revised species had been isolated from different parts of the world. Only two of these hosts, *Piper betle* L., *Piper longum* L. have been recorded from India. In recent years this fungus has been isolated in South India from several host plants which have not been mentioned by Middleton. The disease on these hosts are described in this paper.

On Ginger, *Zingiber officinale* Roscœ

Rhizome rot and wilt of ginger are common in Malabar. *Phythium aphanidermatum* (Eds.) Fitz. has been recognised as one of the causal agents of this disease not only in Malabar but also in other parts of India (Subramaniam 1919, as *Pythium butleri*) and Ceylon (Park 1934). *Pythium myriotylum* Dreschler is another fungus responsible for this disease in Gujerat, Sind and Ceylon (Uppal, 1940; Park 1941). Several isolates of *Pythium* were obtained from diseased rhizomes collected from different parts of Malabar. These exhibited certain differences and were classified into three distinct types. Cultures of these three types had been sent to Mr. S. F. Ashby of the Commonwealth Mycological Institute, Kew, for correct identification, in 1938. He identified the three types as *Pythium aphanidermatum*, *Pythium myriotylum* and *Pythium complectens* (= *Pythium vexans*) respectively. Of these three the last was isolated from rhizomes obtained from Wynaad. This is a submontane tract with an elevation of over 3,000 feet above mean sea level. The isolates from lower elevations were one or other of the other two species.

The symptoms caused by the infection of *Pythium vexans* on ginger are similar to those produced by the other species. In the field, yellowing and wilting of the aerial shoots are common. The associated rhizomes are invaded by the hyphæ. The inner tissues are softened with the development of a watery rot, the outer skin and fibres (vascular bundles) being usually left behind. Besides causing damage in the field a large proportion of seed rhizomes are destroyed in storage. They are as a rule stored in pits soon after harvest and taken out when required for planting, after a lapse of over 5 months. It has often been found that 50 to 90 per cent of these stored rhizomes exhibit considerable shrinkage and are rotten when the pit is opened. It has been possible to minimize storage rot to a large extent by the

treatment of rhizomes prior to storage (Thomas, 1939). Soon after harvest healthy rhizomes are selected and cleaned of all adhering soil. They are then steeped in a 0.1 per cent solution of mercuric chloride for one and a half hours, air dried in shade and then stored in pits. Such treatment reduces the incidence of rot to a considerable extent. Besides the mercuric chloride dip, steeping in suspensions of organomercury compounds, like Ceresan and Agrosan GN (0.25 per cent) for half an hour has also given satisfactory results (Thomas, 1941). The treated rhizomes do not get shrunk and sprout well while the untreated ones are much shrunk and their capacity to sprout is poor.

On Cardamom, *Elettaria cardamomum* Mat.

A disease affecting the rhizomes of cardamom resulting in the wilting of one or more aerial shoots in a clump, is prevalent in different parts of South India *viz.*, cardamom plantations in the districts of Tinnevelly, Madura and Coimbatore and in Travancore state. Two species of *Pythium* viz., *Pythium aphanidermatum* and more often *Pythium vexans* (*Pythium complectens*) (Thomas, 1939) have been isolated from the diseased rhizomes. The rhizomes become softened and are sometimes involved in a wet rot. The shoots arising from these rhizomes wilt, fall out radially and die. It is only rarely that the whole clump is destroyed. Often varying numbers of the shoots are killed. New shoots develop from the unaffected portions of the rhizomes and in course of time some of these may also be affected. The disease is known among the planters as 'clump rot.'

This isolate of *Pythium vexans* resembled closely the one from ginger. It is interesting to note that this isolate was also obtained from elevations of 3,000 to 4,000 feet.

The disease has been kept within bounds by proper manuring (Marudarajan, 1948). Addition of phosphatic manures results in the development of more healthy shoots and a reduction in the incidence of wilting in diseased clumps. Ammonium phosphate and superphosphate applied at the rate of about 2 ounces per clump have given favourable results. Vanterpool (1940) states that in the case of the browning root rot of wheat caused by species of *Pythium*, practical control may be obtained by applying phosphatic fertilizers at the time of sowing. He states that "an unbalanced available phosphorous nitrate relationship predisposed the wheat seedlings to attack by *Pythium* spp. So long as the available phosphorous is deficient in infested soil, nitrogenous applications may even be harmful. Phosphorous is thus the chief limiting element, with nitrogen next in importance. Consequently it is not surprising that ammonium phosphate gives practical control of the diseases in the fields." Similar results have been noted in the case of the cardamom 'clump rot,' caused by *Pythium vexans*.

On *Pelargonium* sp.

The cultivation of this plant has been undertaken on the Shevroy hills (Yercaud) in recent years for the extraction of the geranium oil. During 1946 when there was heavy rainfall in that area an epiphytotic of stem rot occurred in those plantations. Dark brown water-soaked lesions were found on the stem and branches and many of the shoots withered and died. In some of the rooted cuttings the roots were also infected and rotten, resulting in the collapse of the shoots.

Sections of the roots and the stem lesions showed the presence of non-septate hyphæ in the cortical tissues. Surface sterilised bits of diseased tissues produced on incubation growths of *Pythium vexans* with the characteristic sporangia and oospores.

Several species of *Pythium* have been known to cause foot-rot and stem-rot of *Pelargonium*. *Pythium complectens* (= *Pythium vexans*) itself was first described from *Pelargonium*. The isolate obtained from Yercaud was pathogenic to the oil yielding *Pelargoniums* under conditions of high humidity and soil moisture.

On Cinchona, *Cinchona officinalis* Hk. *Cinchona ledgeriana* Wedd. *Cinchona succirubra* Pav. and other hybrids

Planting of cinchona on an extensive scale is being done on the Anamalais at elevations ranging from 3,500 to 4,500 feet. Virgin forests are being cut and planted with cinchona. Casualities of cinchona seedlings and young plants were common in the nursery and in the field in 1948.

Nurseries are raised from seeds and from cuttings. Damping off was more common among the seedlings raised from seed. In the vegetatively propagated nurseries, only the wilting of the sprouts was evident. This was as a rule preceded by rotting of the newly formed roots and the development of water-soaked lesions at the base of the cutting below the soil level. Sections of the affected portions indicated that the tissues were invaded by non-septate hyphæ. *Pythium vexans* was isolated again and again from the diseased tissues. The isolates were identical with those obtained from the other hosts.

Periodic applications of Bordeaux mixture, it has been reported, have reduced the incidence of the disease. In the field casualties are noticed among the plants one to three years old. The leaves become reddened, hang down and defoliation takes place. Eventually the plants are killed. A large proportion of the roots of such plants are blackened and the cortex easily sloughs off from the stele. In some cases the infection extends to the base of the stem. Non-septate hyphæ are present in the cortex and even in the xylem vessels of the roots. Spherical vesicles develop in the hyphæ in some of the cortical cells. Repeated isolations of the fungi from the affected roots and stems consisted invariably of *Pythium vexans*. The disease has been found to be more common in situations where the soil is not easily drained. This isolate of *Pythium vexans* is similar in growth habits to the one isolated from diseased plants in the nursery.

On *Pyrus malus* L.

At the Pomological Station, Coonoor (Nilgiris), apple grafts made on the crab-apple stocks were found to wilt suddenly and die in July 1947. The roots especially were in different stages of rotting, and since the root-stock had been affected, the scion wilted. Three fungi were isolated from the diseased plants *viz.*, *Pythium vexans*, *Rhizoctonia solani* Kuhn and *Fusarium* sp. These were separately inoculated on the roots of crab-apple plants raised from cuttings. There was, however, no sign of positive infection even after 6 months. However, it is evident that *Pythium vexans* is prevalent in this area.

Discussion

The isolates obtained from the different tracts resembled each other in their morphological characters and in growth habits. A luxuriant white aerial growth occurred on oat agar. The hyphæ were fine and freely branching. Sporangia were ovoid, elliptical or spherical and terminal or intercalary. They were sparingly formed on solid media but large numbers developed within 24 hours when bits of culture were floated on water or soil leachate. Germination was mostly by the development of germ tubes. Zoospore formation was rare. Oogonia were formed in 4 to 5 days and were mostly terminal but sometimes intercalary and smooth.

One antheridium was found to be broadly applied to each oogonium. Oospores were aplerotic, smooth and subhyaline to yellowish. They had an average diameter of 18μ.

The observations recorded indicate the widespread distribution of *Pythium vexans* in South India. All isolations have been, however, from localities situated at elevations of 3,000 feet and above only. Several host plants, not previously mentioned are found to be affected. It is thus evident that this fungus must be a common soil pathogen in these areas. There is no record however of its having been isolated from the plains (lower elevation) of the Madras Province. Middleton (1943) writes that the optimum temperature for growth of *Pythium vexans* (and of a strain originally named *Pythium complectens*) is about 28° C. and no growth takes place beyond 34° C. ; while for *Pythium aphanidermatum* and *Pythium myriotylum* the optimum is at about 34° C. and the maximum above 40° C. This differential behaviour in temperature relations probably accounts for the prevalence of *Pythium vexans* at higher altitudes where the temperatures are lower than at lower elevations.

Summary

Pythium vexans has been observed to cause diseases of ginger, cardamom, *Pelargonium*, cinchona and apple trees in South India. The distribution of the fungus however, restricted to hill tracts with elevation of over 3,000 feet above the mean sea level. The isolates from the different hosts resembled each other. The symptoms of infection on the different hosts are described.

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INVESTIGATIONS ON GENERAL RUSTS—II
Uromyces setariæ italicæ (Diet.) Yoshino

BY K. RAMAKRISHNAN

(Accepted for publication March, 31, 1949)

UROMYCES setariae-italicae was first recorded by Yoshino from Japan on *Setaria italica* var. *germanica*. Since then it has been observed from several places in Asia and Africa. In India it has been noticed from Madras, Bombay, Bihar Bengal and the United Provinces (Butler & Bisby 1931). Butler (1918) considered it of little economic importance as it was often found only in the later stages of the crop. In 1944, however, a serious epiphytotic of this rust was recorded in the Ceded Districts of the Madras Province, which led to the drying up of the crop and heavy reduction in yield.

Little work seems to have been done on the morphology, pathogenicity, and physiological specialisation of the rust. The same rust has been reported on *Setaria glauca*, *Setaria intermedia*, *Setaria verticillata* and *Setaria viridis* (Butler and Bisby, 1931; Sydow, H. & P., 1910; Saccardo, 1905). But it is not known whether the same race of rust can pass on from one host to another. The present paper embodies the results of investigations conducted during the years 1947-1948.

The sori.—Uredia develop in large numbers on both sides of the leaf as small oblong, cinnamon brown pustules, often arranged in rows. Urediospores are round or oval, echinulate, with yellowish brown contents and hyaline walls. Three to 4 scattered germ pores can be seen on the wall. They are pedicellate with hyaline pedicels. They measure 26 x 20μ (20-34 x 14-24μ). Telia develop on the leaf blades, sheath and stem in large numbers much later than the uredia. Butler (1918) says that teliospores have been observed occasionally in Japan and once in Bihar. Sydow (1910) also stated that teliospores are very seldom produced in Japan. Observations made at Coimbatore, however, show that telia are not so rare but are abundant in the months of December-January. Telia are greyish black, more deep seated than uredia and remain covered by the epidermis for a long time. Teliospores are of various shapes, oblong, round or polygonal, with a smooth wall thickened at the apex and yellowish brown in colour. They measure 22 x 17μ (17-26 x 14-20μ). A small portion of the stalk remains persistently attached to the spore.

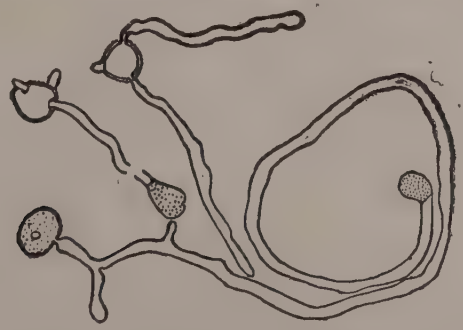

Fig. 1. Germination of urediospores, × 60

Urediospore germination.–Fresh urediospores germinate readily, soon after collection when placed in water or 1-2 per cent sucrose solution. Ninety-five to 100 per cent of the spores germinate in 12-18 hours producing one or more germ tubes emerging through the germ pores. All these do not grow to the same length but only one or

rarely 2 grow very long, producing terminal appressoria of various shapes. The protoplasm is concentrated in the appressorium which is cut off from the rest of the germ tube by a septum. Sometimes branching of the germ tube is evident. Some of the germ tubes are very long and coiled.

The effects of the concentration of sugar solutions on the germination of the spores was tested with fresh spores. It was found that the germination was markedly reduced when the concentration was raised above 3 per cent.

Fig. 2 Appressoria, × 90

Viability of the spores:—The germination of the urediospores was tested at intervals. The rusted leaves were air dried after collection and kept in tissue paper envelopes under laboratory conditions (temperature 28-30° C.). Spores were placed for germination soon after collection and were found to exhibit 99 per cent germination. Germination tests made after a lapse of 15 days showed that the viability of the spores had been completely lost.

The rusted leaves were stored under various levels of humidity, and germination of the spores was periodically tested. For maintaining the levels of humidity the methods described by Wink (1945), Riker and Riker (1936) and Stevens (1916) were followed. The results are given below.

TABLE I

Percentage of germination of urediospores kept for germination on 4-11-48

Relative humidity	On 11-8-48	On 20-8-48	Remarks
1.5	0	0	Dry and brittle
22	34.7	1	
53	10.6	0	
75	26.3	0	Slightly mouldy
86	1.25	0	Very mouldy
100	0	0	„ „

It is seen that the urediospores are viable only for a very short period. But at 1.5, 86 and 100 per cent humidities the viability is lost within one week. At 22 per cent humidity a few spores are capable of germination after 15 days.

Inoculation studies.—Inoculations were made on young plants, 15 days old, grown under rust-free conditions. The leaves were sprayed with a suspension of fresh urediospores in water and the plants were kept in glass cages and covered with bell jars for 48 hours after inoculation, to provide a humid atmosphere. Abundant uredia appeared on both sides of the leaf on the eighth day. Further repetitions confirmed the results and it was established that the incubation period was 7 days. The prevailing atmospheric temperature during the period ranged between 21 and 31° C. Inoculations were also carried out on *Setaria glauca* and *Setaria verticillata*. There was no evidence of any infection on these. Field observations made on plants of *Setaria glauca* growing between rows of *Setaria italica* heavily affected by rust showed that the former were completely free from rust.

Setaria glauca plants heavily affected by rust were collected from Walayar and from the Agricultural Research Station, Nanjanad. The urediospores from these were inoculated on *Setaria italica*. No infection was evident.

The urediospores and teliospores of the rusts on *Setaria italica* and *Setaria glauca* closely resemble each other in appearance. The measurements of the spores on the two hosts are given below :

	Urediospores.	Teliospores.
Setaria glauca	27 x 20μ (20-34 x 14-24)	21 x 17μ (17-27 x 14-20)
Setaria italica	26 x 20μ (20-34 x 14-24)	23 x 17μ (17-27 x 14-20)

The dimensions are almost identical. But physiological specialisation seems to be present as the race on *Setaria italica* does not pass on to *Setaria glauca* and *vice versa*.

Varietal susceptibility.—Field observations were made periodially on the cultures of *Setaria italica* grown at the Millets Breeding Station, Coimbatore. It was found that there was no culture which was immune to the rust. Variations were observed in the intensity of infection. The culture 4054 which was considered resistant was grown in miniature plots alongside Co. 1, 3560, 3396 and 2528. Cultures 3560, 3396 and 2528 were very heavily rusted and the plants dried prematurely without grain formation. Culture 4054 exhibited more than 50 per cent infection and grain formation was partial. Co. 1 exhibited lesser infection than 4054. Weather conditions influence the intensity of infection. Crops maturing during rainless months show very little rust. Heavy incidence is observed in the months of November to January especially if rains fall during these months.

The writer wishes to acknowledge his gratefulness to the Government Mycologist, Coimbatore, for kindly affording facilities for carrying on the work and the Millet Specialist, Coimbatore, for kindly supplying some of the seed material and for permitting the writer to make periodical observations at the Millets Breeding Station.

SUMMARY

The rust of *Setara italica* caused by *Uromyces setariae-italicae* is of common occurrence. The urediospore germination was studied. The urediospores are viable only for a short time under any level of humidity. Evidence is presented to show that

there is physiological specialisation in the rust. All the common strains of *Setaria italica* are more or less susceptible to the rust.

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INVESTIGATIONS ON CEREAL RUSTS—III

Puccinia purpurea Cke

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(Accepted for publication, March 31, 1949)

Puccinia purpurea Cke has been recorded on *Sorghum vulgare* from India, Africa, Southern Europe, the Americas, Australia, Java and the West Indies (Butler, 1918). It has a wide distribution in the warmer regions and in India this rust is common in Madras, Bombay, Bihar and Central Provinces. The loss caused by the rust varies depending on the varieties infected and the environmental conditions. Some varieties of sorghum do not exhibit any appreciable reduction in yield due to the incidence of this disease but others are sensitive to infection and premature drying of the leaves results in much loss of yield (Johnston and Mains, 1931.)

In Madras this rust has been observed in all the districts where the crop is grown. In some districts where sorghum is grown all the year round, it is present almost throughout the year. The incidence of the rust is, however, more in the later stages of the crop. The lower leaves are the first to be infected. The sori develop initially in the upper half of the leaves and later the infection spreads to the basal half. Rainfall favours the incidence and spread of infection. Observations carried out during two seasons (1947 and 1948) have shown that the rust sori are abundant after a spell of rainy weather, whereas before the rains they were few or absent.

The uredia are more common and develop profusely. They are amphigenous but more profuse on the lower surface, appearing as raised pustules. The epidermis is ruptured quickly, exposing the brown spores. Stout, club-shaped or capitate, thick-walled, subhyaline to brown paraphyses occur in large numbers mixed with the urediospores. The spores are oval or elliptic, echinulate, dark brown, pedicellate and measure 36 x 26. μ (27-43 x 21-30μ). Four or five germ pores are present. Soon after collection over 90 per cent of the spores are found to be viable, but the viability is quickly lost in storage.

Fig. 1. Germination of urediospores x125

In order to see how long the urediospores remain viable, fresh collections of rusted leaves were air dried over night and stored in brown paper envelopes in the laboratory (26-29° C.) and in a refrigerator (5° C.) inside desiccators and in petri dishes. It was found that the spores lost their viability after 14 days when the leaves were stored at room temperature. Those kept inside the refrigerator exhibited, however, about 4 per cent germination on the 14th day but this gradually declined and there was no germination after the 20th day. Storage inside desiccators gave better results. But the spores themselves germinated better at the laboratory temperature, 26-29° C. than at 5° C.

Telia usually develop in the months of December and January under conditions prevalent in Coimbatore and its neighbourhood. These are very dark or almost

black and usually develop on the lower surface. Sometimes teliospores are formed in old uredia. Paraphyses are present in the telia also. The teliospores are reddish-chocolate, 2-celled, rounded at the apex and base, with one germ pore in each cell and have long pedicels. Fresh spores germinate in 24 to 48 hours when floated in drops of water or 1 per cent sucrose solution during December and January when the laboratory temperature is about 23-25° C. A long promycelium is formed from each cell. Three septa develop at the upper end of the promycelium and from each cell one round or elliptic basidiospore is produced on a long sterigma.

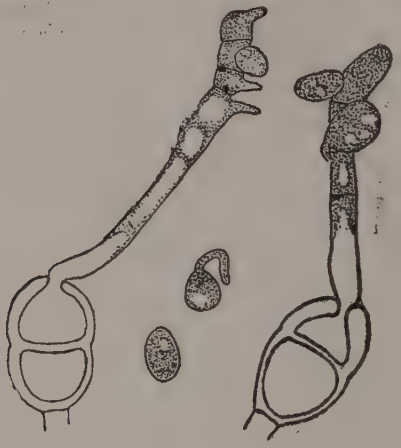

Fig. 2. Germination of teliospores and sporidia. x200

The alternate host of this rust has not yet been discovered. The germinating teliospores were used for inoculating leaves of *Solanum melongena*, *Solanum torvum*, *Withania somnifera*, *Ipomaea hispida*, *Ipomaea aquatica*, *Ipomaea batatas*, *Oxalis corniculata* and *Blepharis boerhaaviaefolia*, but no infection was noticed on any of these hosts. Further trials with other hosts are in progress.

The pathogenicity and the host range of this rust were studied. Inoculations were made on young healthy sorghum plants, 21 to 35 days old, by brushing urediospores on the leaf surface. The plants were kept in glazed cages and were covered by bell jars for 48-72 hours after which the bell jars were removed. Small spots were visible on the 8th day and the pustules developed on the 10th day. In some cases the incubation period extended up to 15 days. It is thus evident that even young sorghum plants are capable of being infected, though in the field the incidence of rust is seen only when the plants are 2 to 3 months old.

On the infected leaves the pustules may be sparse or crowded and the spots may run into one another and coalesce. The colour of the spots varies according to the variety of sorghum. In some it is chocolate, in others deep red and in still others light red or straw coloured. The colour reaction depends on the anthocyanin pigments present in the variety.

Puccinia purpurea has been recorded on cultivated sorghums, Johnson grass (*Sorghum halepense*) and Sudan grass (*Sorghum sudanense*). Several species of sorghum are being grown in the Millets Breeding Station, Coimbatore. These include both the grain sorghums and those grown for fodder. The rust was present on several species of sorghum. Advantage was taken of the availability of these species to find out whether there is any specialisation in this rust.

Healthy, rust free seedlings of all the available species were raised from sterilized seeds. Cross inoculations were carried out with the spores from *Sorghum durra* to others under controlled conditions and *vice versa*. The results are recorded in Table I.

TABLE I

Results of Inoculation experiments on different species of Sorghum

Urediospores from	*durra*	*halepense*	*sudanense*	*nitens*	*verticilliflorum*	*arundinaceum*
Sorghum durra ..	+	+	+	+	+	+
„ *halepense* ..	+	+	—	—	—	—
„ *sudanense* ..	+	—	+	—	—	—
„ *nitens* ..	+	—	—	+	—	—
„ *verticilliflorum* ..	+	—	—	—	+	—
„ *arundinaceum* ..	+	—	—	—	—	+

+ indicates positive infection.
— not tried.

There is no indication of the existence of specialisation of parasitism in the rust. It is able to pass on readily from one host to another and *vice versa* under conditions obtaining at Coimbatore.

With the idea of determining whether the urediospore size is affected by the particular host, measurements were made of 100 spores from each of the different hosts. In addition, measurements of the urediospore on one host and after passage of the same culture through *Sorghum durra* were also recorded. These measurements are as follows.

TABLE II

Measurement of Urediospores

Source of uredia	Size of spores in μ	Measurement of urediospore after passage through *Sorghum durra* in μ
Sorghum durra	36 x 26 (27-43 x 21-30)	
Sorghum halepense	30 x 25 (25-34 x 22-28)	34 x 27 (25-42 x 21-32)
Sorghum sudanense	34 x 24 (25-38 x 21-32)	32 x 25 (25-38 x 21-30)
Sorghum nitens	34 x 24 (30-40 x 19-32)	34 x 28 (30-40 x 21-32)
Sorghum verticilliflorum	30 x 26 (25-33 x 25-31)	31 x 26 (28-37 x 22-31)
Sorghum arundinaceum	31 x 26 (25-37 x 22-31)	31 x 27 (25-33 x 21-31)

The range of measurements does not exhibit any appreciable variation, but the mean size of the urediospore on *Sorghum halepense* is slightly less, although when the rust was inoculated on *Sorghum durra* the spores were bigger and normal.

The different cultures of grain sorghums growing at the Millets Breeding Station were carefully examined periodically and the incidence of rust determined using modified Cobb's scale (Arthur 1931). It was found that almost all cultures included in *Sorghum durra*, *Sorghum cernuum*, *Sorghum subglabrescens*, and *Sorghum dochna* were rusted, the infection varying between 5 and 100 per cent. But cultures of *Sorghum conspicuum*, *Sorghum caffrorum*, *Sorghum nigricans* and *Sorghum caudatum* were completely free from rust. Thus differences in the relative susceptibility to rust is exhibited by several cultures. This has to be confirmed by further observations during other seasons.

I am grateful to Mr D. Marudarajan, Government Mycologist, Coimbatore, for affording facilities for conducting this investigation and to Mr P. Krishna Rao, Millet Specialist, Coimbatore, for supplying materials and allowing me to conduct field studies.

SUMMARY

Puccinia purpurea Cke occurs commonly on sorghum in several parts of the Madras province. The urediospores of this rust remain viable only for a short period. The teliospores germinate readily both in water and in sugar solution. There is no evidence of specialisation of parasitism. Differences in the susceptibility of the several cultures of sorghum have been noted.

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PROBLEMS IN RESEARCH ON VIRUSES AND VIRAL DISEASES

BY FRANCIS O. HOLMES

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IN recent years plant pathologists have found a rapidly increasing need for the study of viruses and viral diseases. Epiphytotics of viral diseases in crops have caused losses the magnitude of which has been recognized progressively. Experimentation with viruses under controlled conditions has continuously yielded new techniques, and, as a result, opportunities for effective control in the field have multiplied. Concurrently, new views of the nature of viruses, especially based on morphological, genetical, and chemical evidence, have emphasized the biological significance of research in this field.

Our present knowledge of viruses and of methods for their study was reached by a long series of successive steps that need not be reviewed in detail here, since modern textbooks (2, 10, 28, 29) have summarized the history of development of this branch of science. Suffice it to say, briefly, that virus diseases were difficult to study a quarter of a century ago. The mysterious filterable entities that were then postulated as their causative agents could be manipulated in most cases only, and in other instances principally, by transferring them from one host to another through grafting or mechanical inoculation, with subsequent observation of induced diseases. Gradual recognition of insect-vector relationships (32) supplied methods of transfer, by vectors, that supplemented earlier techniques. Serological means of identifying viruses permitted unrelated, though similar, viruses to be distinguished and relationships among differing, though fundamentally allied, strains to be established (4, 9). Discovery of easy and rapid methods of measurement for some viruses, as by counting primary lesions (14, 15) or by determining precipitin reaction endpoints (5), permitted manipulations designed to show the chemical reactivity and some of the physical attributes of the still hypothetical units of virus. Various degrees of purification and, in some instances crystallization, of viruses were then attained (3, 20, 24, 25, 30). Electron micrography (17, 21, 31) finally confirmed the particulate nature of viruses, as conceived earlier and to some extent defined by less direct physical measurements, such as of filtration endpoints (11, 35), electrophoresis (33), anisotropy of flow (34), diffusion (23), viscosity (19), and sedimentation in high-speed centrifuges (36).

Now we face many newly conceived, as well as some old but still unsolved, problems connected with viral diseases in plant pathology. In continued study of these, existing techniques for experimentation with viruses may be expected to give us both new theoretical and new practical results, for many of our more recently developed techniques, such as electron micrography (27), transfer of viruses by dodder (6, 16), and isolation of mutant strains (18), have been exploited only partly. Moreover, attempts to solve existing problems may tend to foster development of additional techniques and afford us mastery of as yet unattained viewpoints.

Perhaps the foremost theoretical question that confronts investigators today is whether any filterable virus can be propagated in a lifeless medium. All phytopathogenic viruses are regarded, at present, as requiring living hosts for their self-propagation. It remains a question whether this is not true for viruses in general. But viruses are not unique in this. It is true, for instance, for such organisms as the fungi that cause plant rusts and powdery mildews. Progress in the attempt to grow phytopathogenic viruses in lifeless media may come only after the problem has been solved for supposed obligate parasites such as the rust fungi; or the reverse may occur, for the successful cultivation of a virus may provide also a solution for such a

problem as that of cultivation of a rust fungus. It is by no means clear why viruses should multiply only in living hosts. As an explanation of their apparent inability to multiply in ordinary sterile culture media, it might be assumed, for example, that they require, in addition to food substances available in such an environment, some substance or substances produced slowly in living hosts but utilized rapidly so as never to accumulate in large amounts. Or it might be assumed that a living host assists a virus to assimilate one or more substances that are not assimilable by the virus alone and unaided. Gradually, some viruses that can be studied quantitatively with fair accuracy are being investigated with a view to determining their requirements while within their hosts (26). Eventually these requirements may become obvious keys to the problem and proof of multiplication in lifeless media may then become feasible.

A second problem is whether more definite relationships can be demonstrated between major groups of viruses as now known. Our knowledge of viruses has accumulated in connection with three separate fields of research : plant pathology, human and veterinary pathology, and bacteriology. On this account, we know one large group of viruses as causing diseases in higher plants, another as causing diseases in man and domestic or wild animals, and a third as parasites of bacteria. As yet, no one virus is known to fall definitely into two of these three groups. There is, however, some reason to believe that the groups may not be mutually exclusive in the strictest sense. Some viruses that cause diseases in plants are capable of multiplying also, though without causing obvious disease, in their insect vectors (7, 8, 12). The finding that a virus may be formed from constituents of a plant or an animal (that is, an insect vector), even though without causing obvious disease in the latter, seems to mean that there is a definite possibility of overlap between at least two of the three groups of viruses. Further information of this sort may affect radically our views about viral relationships.

Not all investigators are agreed that viruses should be viewed as living organisms. A decision on this problem may well come eventually as a by-product of numerous investigations rather than as an immediate result of continued research directed specifically toward solution. Characteristics that seem now to suggest that viruses may be tiny living entities are the ability of these pathogens to multiply in suitable hosts, often of very diverse sorts, as do larger and structurally more complicated obligate parasites ; their tendency to mutate occasionally with production of self-propagating variants better or worse suited to survival in specific environments, and their possession of nucleic acid components and of antigenicities that are in general distinct from those of their hosts. These qualities are essentially confined elsewhere in nature to living organisms. Characteristics that have been considered to oppose the view that viruses are living entities are small size, tendency to form crystalline aggregates, and relatively high specific gravities, all of which may be allied qualities dependent on lack of certain mechanisms unnecessary for viruses as highly specialized parasites.

The broadening of our knowledge of the virus field depends on an attack soon on another complex problem, namely : Are some large groups of plants and animals naturally immune to all viral diseases ? We know viruses as parasites of seed plants and bacteria, as well as of mammals, birds and insects. A few less well established cases are reported for other groups. Why, though, are there no authenticated cases of viral diseases of ferns, mosses, or algæ ? Why do the phages that attack bacteria have no obvious counterpart as parasites of fungi ? Why should protozoa seem to be immune as a group ? Why have there been no reports of viral diseases of

crustacea or of mollusca, some species of which have been studied assiduously because they are of practical interest to mankind? Among insects, viral diseases occur in a considerable number of species in the order Lepidoptera (moths and butterflies) and in one species (the honey bee) in the order Hymenoptera. Can it be that the much studied Diptera (true flies) and Coleoptera (beetles) are solidly immune to such attack? Not a single viral disease of these has been reported, unless CO_2-sensitivity in Drosophila (13) can be so construed. Can it be that some kinds of plants and animals are immune to all viruses? Perhaps it is merely our ignorance, soon to be dispelled, that paints this curious picture of the distribution of viruses in nature. A measure of fame awaits investigators who may change our knowledge in each of these respects. If no one can change it, we must seek to understand the method or methods by which these large groups of living things may have found it possible to defend themselves completely against viral attack. Such methods might prove applicable to the defense of cultivated plants, domesticated animals, or ourselves, against viral diseases.

A problem is posed also by supposed differences in breadth of host ranges. We know that some viruses are able to infect many kinds of plants, even though these belong to highly diverse families. Notable examples are spotted-wilt virus and cucumber-mosaic virus, the known natural hosts of which are both numerous and diverse. Some well-known viruses, on the other hand, seem to be of much more restricted host-range. Thus, sugar-cane mosaic virus is known only as affecting plants of a single family, the Gramineæ. Dahlia-mosaic virus, common wherever dahlias are grown, has not been observed to infect plants beyond the limits of a single genus, *Dahlia*. Potato spindle-tuber virus, despite easy mechanical transmission as well as facile transfer by insect vectors, is known only as infecting a single plant species, *Solanum tuberosum* L. At present, about 22 per cent of our fairly well-known phytopathogenic viruses are recognized as having natural or experimental hosts in more than one family of plants; about 27 per cent are known to infect plants in two or more genera within a single family; about 20 per cent are reported to infect two or more species within a single host-genus; and about 31 per cent are known only as infecting one species of plant. If this is merely a picture of our ignorance, continued study of viruses known in but a single species of host may soon change both our fund of organized knowledge and some of our views on practical control of disease. Intensive study has failed to extend the known narrow host range of a few viruses, but further investigation is needed for others.

Our knowledge of insect vectors is changing rapidly. At present a little more than half (about 53 per cent) of our fairly well-known viral diseases of higher plants have been shown to be carried by insect vectors. We know that a few viruses, such as that of tobacco-mosaic disease, are independent of insect vectors in the limited sense that they have other effective and efficient means of spreading from diseased to healthy plants, especially through contaminative and abrasive contacts. We do not know, and shall hardly expect to prove, that any such virus entirely lacks insect vectors, though proof of vector-relationships may be long deferred for viruses the transfer of which by vectors is a minor means of spread at present.

It is a question whether we know yet the full extent of insect-vector types. There remain possibilities of more or less distant allies of known insect vectors acting as occasional or regular transmitters of disease. Their discovery may close part of a gap in our knowledge, for some viral diseases have been investigated extensively without incrimination of vectors even when these must be assumed to exist in order to account for spread of disease in nature.

A geographical problem may assume increasing importance soon. Certain groups of viruses seem to be somewhat localized. A large part, though not all, of the leafhopper-transmitted yellows-disease group of viruses is thought to be confined to North America, possibly because these viruses originally evolved there and many of them have not spread widely. On the other hand, white-fly transmitted leaf-curl viruses have not yet been shown to occur in North America and have been found principally in Africa and Asia. In contrast, aphid-transmitted mosaic-disease viruses seem to be world-wide in distribution. Relatively few groups of viruses are clearly delineated as yet. Further investigation is likely to increase the number of obviously coherent groups among known viruses and to add to our knowledge of geographical localization. Selection of breeding material for investigations on heritable resistance to viral diseases is facilitated by knowledge of geographic boundaries for pathogens and hosts, because natural selection of rare or occasional resistant mutants tends to preserve and increase such plants in endemic areas.

It is by no means probable that we now know all the types of virus that exist. Novel and now unrecognizable kinds may be discovered in the future, with distinct groups of separate viruses within such types. It is important that the field should be developed broadly, by an adequate study of economically important and unimportant viruses alike, to avoid an incomplete and unbalanced knowledge of viral relationships. Naturally, viruses that cause important diseases and viruses that are easy to manipulate in the laboratory have been studied most. More attention should be given to viruses that are found only occasionally or that seem to do little harm. Preparedness thus acquired may be worth more than intensive but hasty study of these same viruses in subsequent epiphytotics. Investigation of a pathogen after it has become important tends to be very expensive, because economic losses continue until research has progressed far enough to afford means of control. In research on viruses, as in other fields, an ounce of prevention is worth a pound of cure and nearly equal study of all viruses without respect to their practical significance will aid in preparedness and promote a balanced development of the field that will be an added benefit.

A problem connected with serology has long been recognized. Some phytopathogenic viruses have proved highly antigenic. Antisera specific for these, developed by injection of animals, have been used as a means of detection, identification, and quantitative measurement, for the determination of minor differences among related strains, and for other technical purposes. Other viruses have not proved similarly antigenic, however. Antisera specific for them would be useful. Can such tools for research be developed ?

Repeated attempts have been made to transfer most viruses mechanically from host to host. Thus far, however, less than half (about 43 per cent) of the fairly well-known viruses have proved transmissible from diseased plants to potentially susceptible healthy plants by means of mechanical inoculation. Only biological means of transmission have been successful for the others. Study of the strictly biologically-transmitted viruses would be greatly accelerated if mechanical means of transmission could be devised to replace transfer by insect vectors, dodders, and grafting in laboratory experimentation.

Can some efficient means be devised for measuring viruses even when they are not mechanically transmissible ? Or can adquate means not involving quantitative measurement be found for studying the physical and chemical properties of mechanically nontransmissible viruses ? If so, the yellows-type viruses may share attention that has been largely concentrated on mosaic-type viruses in the past.

Some viruses that are mechanically transmissible, and many that are not, are so unstable that their extensive manipulation in the laboratory has not proved feasible. A highly effective method or methods for preserving the viability of labile viruses during experimentation would greatly facilitate study of their physical and chemical attributes. Progress has been made by use of reducing agents to minimize oxidation (1), by working at temperatures just above 0° C. (7), and, for periods of storage, by rapid and complete drying at low temperatures (22), but auxiliary methods are needed.

Problems of control of viral diseases have been uppermost in the minds of many plant pathologists during the past. Can new procedures be devised to supplement or replace existing methods of control ? We have now such methods as :

1. Removal of diseased crop plants.
2. Destruction of diseased weeds
3. Isolation of seed plots
4. Isolation of fields
5. Choice of season for planting.
6. Practice of crop-free periods
7. Destruction of insect vectors
8. Use of repellants for insect vectors
9. Indexing and certifying stocks.
10. Production and use of resistant varieties.
11. Cure of disease by heat.

Current investigations are seeking to add to this list such procedures as cure of disease by chemical means. If viruses could be destroyed within their hosts by administration of specific poisons, a new mastery of viral diseases might be attained. Such a development, should it occur, would probably imply discovery of reactive and characteristic chemical groupings within the viruses. Thus it might have as profound an effect on our knowledge of viral structure as on the practical problem of plant protection. It is not yet clear whether chemical therapy eventually will become an important means of control. Perhaps, instead, wholly unanticipated modes of control may be devised.

Genetic resistances to viral diseases, invaluable where available, are utilized as yet in but a small proportion of all problems of control. The ultimate economy of breeding methods for transfer of genetic mechanisms capable of controlling viral diseases commends to the plant pathologist of the future a continued search for additional sources of heritable resistance.

Beside the above-mentioned problems, there are many others. How, for example, do viruses multiply once they are in favorable host-tissues ? How do they produce their often obviously deleterious effects on the hosts ? What is the relationship of viruses to tissues of their insect vectors ? New problems, in addition to such as have been discussed, tend to arise as research discloses the natural complexity of the field of study.

There are many evidences that viruses, like higher organisms, are the products of long processes of evolution and that they do not normally arise by chance aggregation of their constituent parts in the absence of antecedent viral particles. No one, probably, supposes that viruses could not arise *de novo,* but the extreme improbability and hence extraordinary infrequency of their formation in this way coupled with the great frequency of their formation from antecedent viruses would seem to make adequate proof of any *de novo* origin very unlikely.

However complex viruses are, we may assume that they are much less complex than ordinary microorganisms. A typical virus is of the order of a hundred thousandths the volume of an ordinary bacterium. It may be roughly spherical, rod-like, or of other shape. Among rod-like viruses, some are so thin that no great number of atoms lie between the outer surface and any specified inner structure of the virus. Because of this, the chemical reactivity of a larger proportion of a virus is exposed to test than is the case with a bacterium or a protozoon. On the other hand, within a rod-like particle like that of tobacco-mosaic virus, there may yet be several million atoms, doubtless with relationships to each other too complicated to be understood soon in their entirety. Yet small groupings of these atoms, as in the nucleic acid fraction or in the amino acids, may prove understandable in function. For this reason, viruses lend themselves especially well to a study of the nature of mutation and of the essential characteristics of life itself. No better opportunity to investigate the chemical changes accompanying and underlying mutation has yet appeared in the whole field of biology. Some viruses can be withdrawn from their hosts, treated chemically, and replaced as no part of the genetic mechanism of the host can be, at present. Thorough investigation of mutants among viruses will mark a substantial advance in biological science.

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DOWNY MILDEW ON ELEUSINE CORACANA AND ISEILEMA LAXUM IN MYSORE

BY M. J. THIRUMALACHAR AND M. J. NARASIMHAN

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ELEUSINE coracana Gærtn. commonly known as ragi is an important cereal crop in Mysore, South India. With the exception of a grain smut and *Helminthosporium* foot-rot, very few diseases of economic importance are known on ragi. In 1944 the senior author collected during the month of November stray samples of ragi heads showing marked proliferation of the floral parts. Detailed examination of the malformed spikelets revealed that they were not cases of teratological phenomena but were due to infection by a species of *Sclerospora*. The importance of *Sclerospora* species to various valuable gramineous crops either inciting disease directly or by acting as reservoirs has been pointed out by Weston who has contributed considerably towards our knowledge of the genus.

During the months of November and December, 1945, several ragi fields in Mysore were surveyed with a view to find out the incidence and spread of the disease. Stray samples were collected in most of the places except at one spot near Challekere, where about five per cent of the plants were diseased. No observations were made in 1946 and 1947. In the growing season of 1948, a small plot of ragi field near Bangalore showed very severe outbreak of the disease and the farmer complained that the crop was not worth harvesting. Venkatarayan (1947) records the occurrence of a *Sclerospora* species on ragi in Mysore without giving descriptions of the fungus.

The downy mildew on *Iseilema laxum* Hack., a common pasture grass, has been collected in only one place near Nandi Hills, Mysore, at an elevation of 4800 feet above sea level. The diseased plants are very conspicuous due to witches broom-like appearance incited by the systemic invasion of the host by the *Sclerospora* species.

Effect on the Host

On *Eleusine coracana* the fungus incites proliferation *i.e.* the conversion of the spikelet above the first glumes into a leafy shoot. The lower spikelets in the ear proliferate at first, gradually involving in some cases the whole ear (Figs. A & I). The leafy shoots produced as a result of proliferation are upright and present a brush-like appearance. No shredding of the leaves has been observed.

Infected plants of *Iseilema laxum* present a more striking appearance than ragi. The healthy plants usually grow to a height of 3 feet bearing lax spikelets. In the infected plants the internodal elongation is reduced and the spikelets branch excessively and proliferate. This results in a witches broom-like growth of the entire inflorescence (Fig. C). The diseased plants are paler in colour but show no shredding of the leaves.

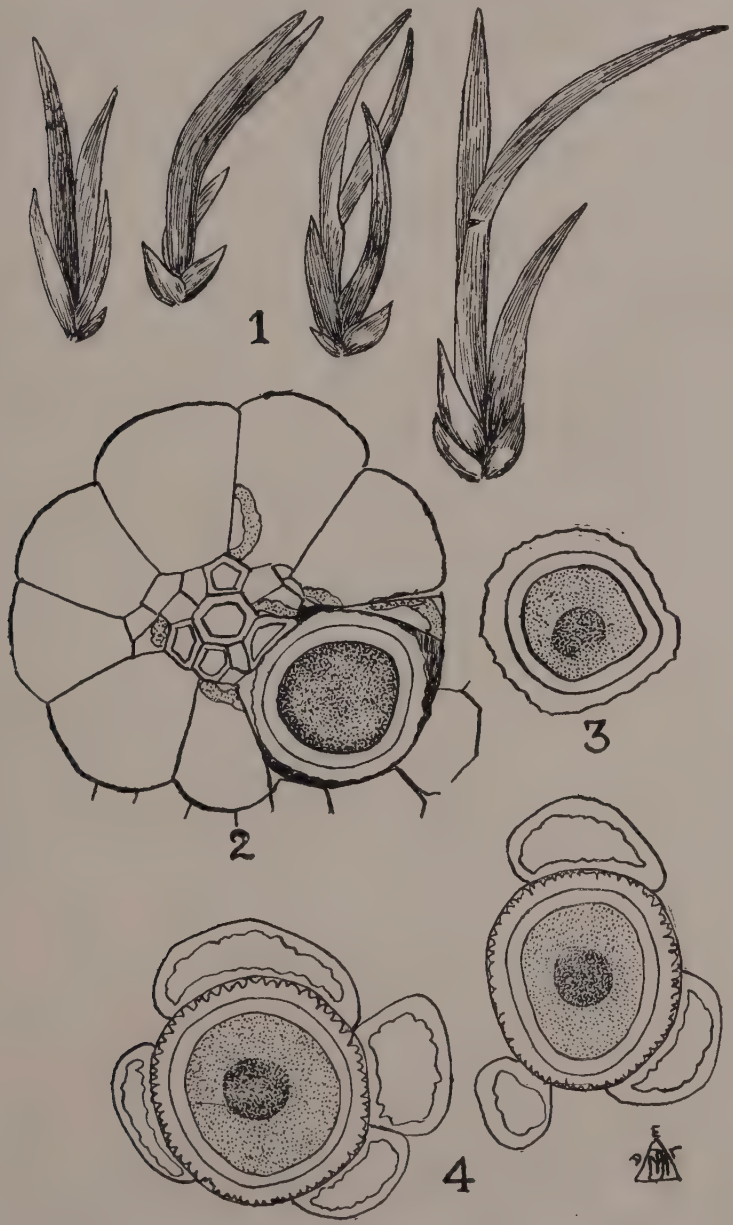

Fig. 1 to 4. See legend.

Characteristics of the Fungus

Sections through the proliferated portions of the ragi spikelet revealed the presence of irregular contorted hyphæ in the interstices of the host cells (Fig. 2). The

conidial (sporangial) stage has not been observed either on *Elusine coracana* or *Iseilema laxum*.

The oogonia and oospores are formed in the proliferated parts. In *Eleusine coracana* they are sparsely distributed, being produced within the mesophyll cells surrounding the vascular bundles (Figs. B & 2). The wall of the oogonium is thickened up to 4μ and is slightly undulated. Mature oogonium is globoid, pale cinnamon-yellow and possesses dense granular contents. Antheridium is usually single and does not persist in the mature oospore.

The mature oospores are thick-walled (wall up to 3μ thick) enclosing granular cell contents and oil droplets. As in other species of *Sclerospora*, the walls of the oogonium and oospore are confluent.

In contrast to *Eleusine coracana*, the proliferated spikelets of *Iseilema laxum* contain numerous oogonia and oospores produced within the mesophyll tissue between the vascular bundles (Fig. E). In most of the cases the developing oospores push the vascular bundles on either side and crush them (Fig. D). The oogonia are numerous and fill up the mesophyll tissue between the epidermal layers. Mature oogonia are globoid and golden-yellow in colour. The walls are up to 5.5μ thick and deeply folded to present a tuberculate appearance in surface view. The antheridia are 2 to 5 in number, conoid and closely adpressed to the oogonial wall. The mature oospore is spherical, thick-walled and possesses granular cell contents and few oil droplets. The wall is up to 3.5μ. thick, smooth and confluent with the oogonial wall. The remnants of the old antheridia can be seen as hemispherical bulges on mature oospores (Fig. 4).

Identity of the Fungus

Since the conidial stage is unknown for either of the fungi under study, comparison with other species of *Sclerospora* has to be made only as regards oogonia and oospore stages. In the fungus on ragi, the oospores are up to 60μ in diam., pale cinnamon-yellow, and closely resemble those of *Sclerospora macrospora* Sacc. Recent investigations by the senior author (Thirumalachar, 1949) on *Sclerospora macrospora* on grasses have confirmed the previous findings of Peglion (1930) and others, that that fungus is not a species of *Sclerospora*. In the absence of our knowledge about the conidial stage of the fungus on ragi, we defer naming of the fungus. The diagnosis for the oogonial stage is as follows :

Inciting phyllody of floral parts and giving a brush-like appearance. Oogonia formed in the mesophyll cells surrounding the vascular bundles, sparse, subglobose to spherical, 34-70 x 36-62μ, pale-cinnamon-yellow, wall 3.5-4μ thick, and sinuous. Antheridia usually single, not persistent in the oospore. Oospores spherical, 35-60μ in diam. with granular contents; wall 2.5-3μ thick, confluent with the oogonial wall. Germination not observed.

Hab. In the spikelets of *Eleusine coracana* Gærtn. Bannerghatta, Bangalore, 14-11-1944, leg. M. J. Thirumalachar.

The oogonial stage of the *Sclerospora* on *Iseilema laxum* is quite distinct from those of other species. The oogania measure 43-61 x 40-54μ and the wall is up to 5.5μ thick and deeply folded. The antheridia are 2 to 5 in number and persist even in the mature oospore. The oospores measure 38-50μ in diam. and are comparable with those of *S. farlowii* Griff. occurring on *Chloris elegans* in the United States. The oospores of the latter, however, are of a deeper shade and more opaque than in the species on *Iseilema laxum* where they are pale golden-yellow. Comparisons with other oosporic species of *Sclerospora* reported by Weston (1929[a], 1929[b], 1933) and others (Weston and Uppal, 1932) indicate that the present species on *Iseilema laxum* is undescribed.

SCLEROSPORA ISEILEMATIS Thirum. & Narasimhan *sp. nov.*

Inciting proliferation of floral parts, dwarfing of the internodes and giving a witches-broom effect. Conidial stage not observed. Oogonium subglobose to spherical, 43-61 x 40-54μ, pale golden-yellow in colour, wall 5.5μ thick, deeply folded and presenting a tuberculate appearance in surface view ; antheridia 2 to 5 in number, coniod to triangular, 27-40 x 15.5-27μ, persistent in mature oospore. Oospore situated in the centre of the oogonium, spherical, 38-50μ in diam., inner contents granular and enclosing few oil droplets ; wall 3 to 3.5μ thick, hyaline, and confluent with the oogonial wall. Germination of the oospore not observed.

On *Iseilema laxum* Hack., Nandi Hills, Mysore, leg. M. J. Narasimhan and H. C. Govindu, 20-1-1947 (type).

Proliferationem inducit atque partium floralium, spatia internodalia contrahit, effectumque producit vulgo "witches broom" vocatum. Conidia haud observata. Oogonia subglobosa, ad spherica, 43-61 x 40-54μ, pallide lutæ ; parietes 5-5.5μ crassi, profunde plicati atque in aspecto superficiali tuberculati. Antheridia 2-5 numero, conoidea ad triangularis, 27-40 x 15.5-27μ in matura oospora persistentibus. Oosporæ sitæ in medio oogoni, sphæricæ 38-50μ in diam., quæ intus continenture granulata atque nonnulas olei guttulas includentia, parietibus 3-3.5μ crassis, hyalinis atque confluentibus cum oogoni partietibus. Germination haud visa.

Hab. in *Iseilematis laxis* Hack.

DISCUSSION

The record of the occurrence of *Sclerospora* species on *Eleusine coracana* and *Iseilema laxum* in Mysore, adds 2 more representatives to the list of gramineous hosts to this destructive genus. *S. iseilematis* has so far been collected only from one locality in Mysore and its distribution in other places is as yet unknown. Its oospores are quite different from those of *S. sorghi* (Kulkarni) Weston and Uppal and *S. graminicola* (Sacc.) Schroet. which occur on *Sorghum* and *Pennisetum* in the same locality where *S. iseilematis* was collected.

The downy mildew on *Eleusine coracana* seems to be a potential menace in the ragi growing areas. Only sporadic and localised distribution of the disease is usually noticed, though with the advent of favourable conditions it may incite an epiphytotic as was observed in some areas near Bangalore.

The writers wish to acknowledge their indebtedness to Rev. Father Dr. H. Santapau, Professor of Botany, St. Xavier's College, Bombay, for kindly translating the diagnosis of the new species into Latin.

Bangalore, India

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————, and Uppal, B.N. (1932). ... The basis for *Sclerospora sorghi* as a species. *Phytopathology* **22** : 573-586.

Fig. A to E See legend.

EXPLANATION OF FIGURES

A. Diseased and healthy ears of *Eleusine coracana* (nat. size).
B. Showing the formation of oospore x 200.
C. Healthy and diseased spikelets of *Iseilema laxum* (nat. size).
D. Oospores replacing the vasuclar bundles in *Iseilema laxum* x about 200.
E. Oospores of *S. Iseilematis* developing between the bundles x 350.

Fig. 1. Proliferated spikelet of *Eleusine coracana* x 5.
Fig. 2. Oospore formation in *E. coracana* x 500.
Fig. 3. Mature oospores of the same x 500.
Fig. 4. Oospores of *S. iseilematis* x 750.

PRODUCTION OF OOSPORES BY SCLEROSPORA SORGHI ON MAIZE

BY M. K. PATEL

(Accepted for publication April 3, 1949)

SIX species of *Sclerospora* have so far been recorded on maize (*Zea mays* L.) Raciborski (1897) was the first to record it on this cereal in Java, which he named *Peronospora maydis*. Butler (1913) who found a *Sclerospora* on the same host in India thought that he was dealing with the same fungus and transferred it to the genus *Sclerospora* as *Scl. maydis* (Rac.) Butler, which name has priority over the binomial proposed by Palm (1918). Butler however erred in considering the Indian *Sclerospora* to be the same as the Javan species, and Uppal and Weston (1936) have shown that it is in fact *Scl. philippinensis* Weston. Other species recorded on maize are *Scl. sacchari* Miyake (1911) by Subramanian (1931) in India, *Scl. graminicola* (Sacc.) Schroet. reported by Melhus, Van Haltern and Bliss (1928), *Scl. spontanea* Weston, reported by him from the Philippines (1921) and *Scl. sorghi* (Kulkarni) Weston and Uppal (1932) reported on maize both by Uppal (1931) and Melchers (1931). Cugini and Traverso (1902) have recorded *Scl. macrospora* Sacc. forming oospores on this host, but it is not truly a representative of the genus *Sclerospora* because its non-sexual stage does not involve tree-like conidiophores but unusual, single, large *Phytophthora*-like sporangia borne on short stalks, and accordingly it has been renamed *Phytophthora macrospora* (Sacc.) Ito and Tanaka (Tanaka 1940). It should be noted that the name *Scl. indica* proposed by Butler (Butler and Bisby, 1931) for the Indian fungus is a later homonym of *Scl. philippinensis* Weston, for, Uppal and Weston (1936) have proved beyond any doubt that these two species are identical.

On August 20, 1940, leaves of maize, variety Kashmir Sweet, were found on the Agricultural College Estate at Poona to be badly affected by the downy mildew. A careful examination showed that a large number of oospores had also formed. These were not arranged in a linear manner and there was no shredding of the leaves, which is a common phenomenon on other hosts where oosporic stages of species of *Sclerospora* have been noted. None of the other varieties also affected by the disease showed the presence of oospores.

As the oosporic stage has not been reported on any of the several more definite species of *Sclerospora* with the non-sexual stage bearing conidia or sporangia on tree-like conidiophores, a more detailed study of this fungus which had formed it, merited study.

Heavily infected plants of the variety Kashmir Sweet were stunted and not more than a foot in height.

Conidiophores.—The conidiophores of *Sclerospora* on Kashmir Sweet maize have a swollen base, one septum midway between the branching and the base, branches starting from one common place giving it a hemispherical shape. Average length of conidiophores is about 220μ and it will be noted that they resemble those of *Scl. sorghi* in this respect (Text Figs. A. 1-6).

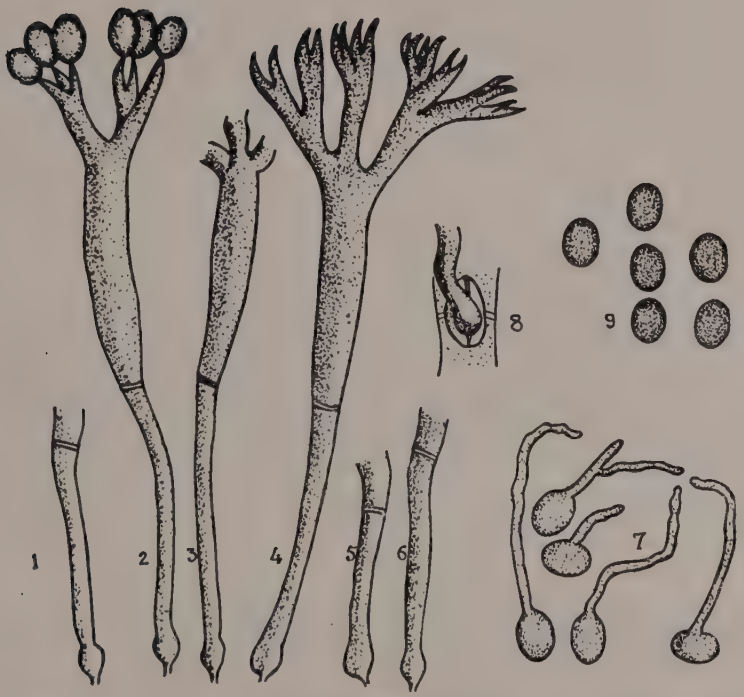

Fig. A. 1 to 6. Conidiophores showing slender, isodiametric, relatively long basal cell, well-developed branch system, bearing conidia in hemispherical arrangement, definite swollen base and a septum in the middle of the conidiophores.

7. Conidia showing germination by germ-tubes.

8. Conidiophores emerging out of a stoma.

9. Mature conidia lacking apical papilla. × 250.

Conidia.—In order to get a correct idea of the shape and the size of the conidia of this downy mildew, 100 conidia were measured using a filar micrometer and a frequency table was prepared which is recorded in Table I. It will be seen that conidia measure 17-29 x 15-27μ on *Zea mays* while those of *Scl. sorghi* are 15-29 x 15-27μ on *Sorghum vulgare* as reported by Weston and Uppal (1932) and Uppal and Desai (1932). The conidia are suborbicular and non-papillate (Text Fig. A, 9) and therefore germinate by the formation of germ tube (Text Fig. A, 7).

TABLE I

Measurement of conidia of Sclerospora sorghi *on Kashmir Sweet maize*

Length		Diameter	
Classes in μ	Number in 100	Classes in μ	Number in 100
17–18.9	1	15–16.9	7
19–20.9	6	17–18.9	10
21–22.9	43	19–20.9	55
23–24.9	28	21–22.9	14
25–26.9	17	23–24.9	8
27–28.9	5	25–26.9	6

Oospores.—Melhus, Van Haltern and Bliss (1928), and Uppal and Desai (1932) had used sweet maize in their cross inoculation studies using oospores of *Scl. graminicola* and *Scl. sorghi*, but did not observe oospore formation as none had apparently formed. In shape and general size, the oospores of *Sclerospora* on Kashmir Sweet maize seemed to agree so closely with those on *Sorghum vulgare* that it was thought necessary to measure 200 oospores of this *Sclerospora* and then to arrange them in a frequency table (Table II). It will be seen that these measure 24-42μ on Kashmir Sweet maize, whilst Weston and Uppal (1932) have reported 25-43μ on *Sorghum vulgare*. Micro-photographs of typical oospores of *Sclerospora* from *Sorghum vulgare* and Sweet maize are given (Plate 1, Figs. 3 and 4).

From the data recorded in Table II and the Figures 3 and 4 shown in Plate 1, it will be seen that there is no noticeable difference between the oospores on sweet maize and sorghum. The major and only difference is in their location, (Plate 1, Figs. 1 and 2), for they are scattered in Kashmir Sweet maize whereas they are arranged in a linear manner in *Sorghum vulgare*.

TABLE II

Measurements of oospores of Sclerospora sorghi *on Kashmir Sweet maize*

Diameter		Width of wall	
Classes in μ	Number in 200	Classes in μ	Number in 200
24–25.9	4	0.7–1.2	11
26–27.9	18	1.3–1.8	28
28–29.9	31	1.9–2.4	72
30–31.9	41	2.5–3.0	51
32–33.9	44	3.1–3.6	35
34–35.9	32	3.7–4.2	3
36–37.9	23		
38–39.9	5		
40–41.9	2		

In Table III are recorded the comparative measurements of the conidia, oospores and the oosporic wall from which it will be quite evident that both the species are morphologically identical.

TABLE III

Comparison of the conidia, oospores and the oosporic wall of *Scl. sorghi*, on *Sorghum vulgare* and Kashmir Sweet maize.

Kind of spores	on *Sorghum vulgare**	on Kashmir Sweet maize	Remarks
	Measurement in μ		
Conidia	15–29 x 15–27	17–29 x 15–27	Range
	21–25 x 19–23	21–25 x 19–23	Majority
		15–29 x 15–27	Range*
		19–25 x 19–23	Majority*
Oospores ..	25–43	24–42	Range
	31–37	30–34	Majority
Oosporic wall ..	0.3–4.0	0.7–4.0	Range
	1.0–3.0	2.0–2.5	Majority

*from Weston and Uppal (1932) and Uppal and Desai (1932).

In order to find whether the oospores from *Sorghum* are able to infect Kashmir Sweet maize and *vice versa*, inoculation experiments using the same technique as that advocated by Uppal and Desai (1932) were carried out in the rainy seasons (July to October) of 1943, 1944 and 1945. The results in all the years were identical in that the oospores were produced in Kashmir Sweet maize and *Sorghum vulgare* only when the infecting material was oospores either from the Kashmir Sweet maize or *Sorghum vulgare*. It is of particular interest to note that the oospores in Kashmir Sweet maize are produced sparingly and that too at a later stage of plant growth. However, on the ordinary maize, only the conidial production occurs but not the oospores.

SUMMARY

The measurements of conidiophores, conidia and oospores of a *Sclerospora* from Kashmir Sweet maize were made and compared with those from *Sorghum vulgare*. The oospores from Kashmir Sweet maize and *Sorghum vulgare* readily infect each other.

The *Sclerospora* producing oospores in Kashmir Sweet maize is morphologically and pathologically identical with that found on *Sorghum vulgare*.

The writer is greatly indebted to Dr B. N. Uppal, Director of Agriculture, B. P., Poona for encouragement during the progress of this investigation and to Dr B. B. Mundkur for suggestions in preparing the manuscript.

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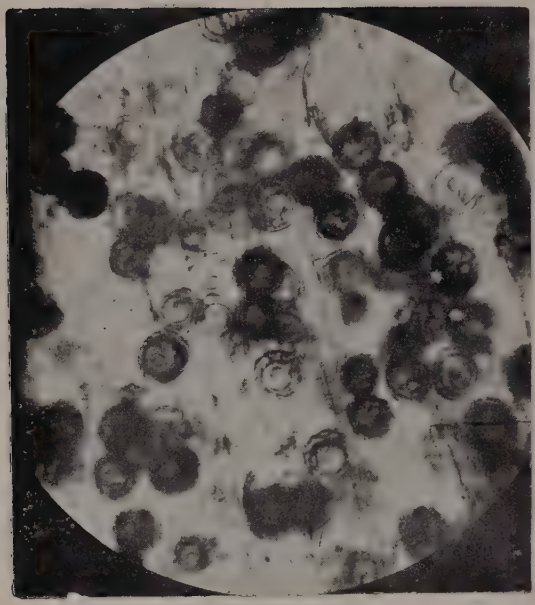
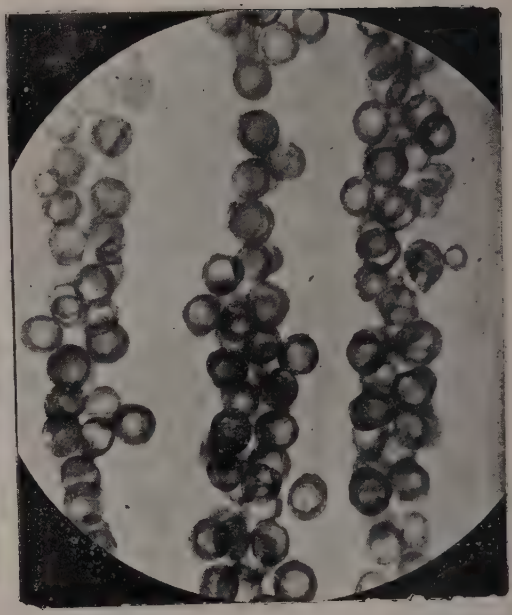
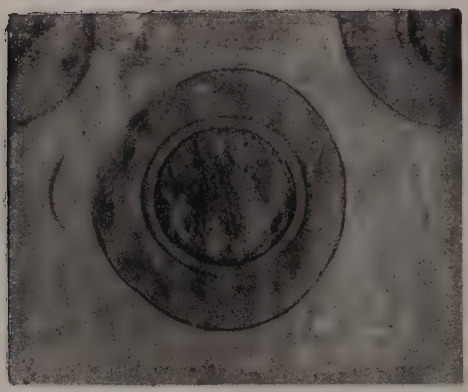
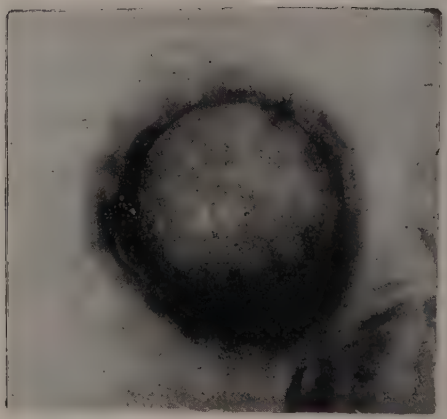
PLATE I.









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EXPLANATION OF PLATE

Fig. 1. Photomicrograph of a portion of leaf of *Zea mays*, showing the irregular arrangement of oospores in the mesophyll tissues. x 160.

Fig. 2. Photomicrograph of a portion of leaf of sorghum, showing the linear arrangement of oospores in the mesophyll tissues between the fibrovascular bundles. x 160.

Fig. 3. Resting spore, showing the single enclosed oospores in *Zea mays*. The content is granular. x 800.

Fig. 4. Resting spore, showing the single enclosed oospores in Sorghum. The content is granular. x 800.

BLACK ROT OF CABBAGE

BY M. K. PATEL, S. G. ABHYANKAR AND Y. S. KULKARNI

(Accepted for publication, April 3, 1949)

BLACK rot of cabbage is probably one of the several plant diseases introduced into India with cabbage seeds which are annually imported from countries where this disease is prevalent.

It may be of interest to review the position of investigations of bacterial plant pathogens in India. As Smith (1920) has stated, India is *terra incognita* as far as this field of investigation is concerned. According to Fawcett (1936) *Xanthomonas citri* (Hasse) Dowson must have migrated from India to other countries since the earliest records show that it was present in the specimens collected in the Himalayas in 1827-1831. Probably another bacterial disease which might have left the shores of this country is *Pseudomonas mangiferæ-indicae* on mango, a fruit *par excellence* of India, which Patel, Moniz and Kulkarni (1948) consider to be quite similar to that described by Doidge from South Africa in 1915.

On the other hand, there are reasons to believe that *Pseudomonas solanacearum* Smith, *Erwinia aroideæ* (Townsend) Holland, *Xanthomonas cucurbita* (Bryan) Dowson, *Xanthomonas phaseoli-sojense* (Hedges) Dowson, *Xanthomonas phaseoli-indicus* Uppal, Patel and Nikam, *Xanthomonas malvacearum* (Sm.) Dowson and *Xanthomonas vignicola* Burkholder have gained entrance into this country from the West along with seed. These organisms have established themselves firmly as has been shown by Mann and Nagpurkar (1921), Ayyar (1927), Prasad (1931), Uppal, Patel and Kamat (1938), Uppal, Patel and Nikam (1946), Patel and Kulkarni (1948) and Diwan (1948).

Other diseases which have so far been reported from India are those on betle-leaf caused by *Pseudomonas betlis* (Raghunathan, 1928) Bergey *et al.* and another on wheat caused by *Corynebacterium tritici* (Hutchinson, 1917) Bergey *et al.* *Bact. pyocyaneus-saccharum* Desai and *Bact. fructodestruens* Madhok and Fazal causing rots of frozen sugarcane tops and of tomato fruits as reported by Desai (1935) and Madhok and Fazal-ud-din (1943) respectively, may be of doubtful origin, as the organisms are not pathogenic on living host parts. Leafspot on *Desmodium diffusum* DC. caused by *Xanthomonas desmodii* Uppal and Patel, on *Desmodium gangeticum* DC. caused by *Xanthomonas desmodii-gangeticii* Uppal, Patel and Moniz as reported by Patel and Moniz (1948) and on *Ipomoea muricata* caused by *Xanthomonas Uppalii* Patel as reported by Patel (1948) are probably also endemic to India.

Black rot of cabbage might have been present in India for a long time but the first authentic report of its occurrence was made by Patwardhan (1928). Since then it is causing severe losses in cabbage all over the country specially near the big towns where the fileds are heavily manured and cabbage grown year after year. Recently, black rot symptoms were noted in other cruciferous crops such as cauliflower, radish, turnip, knol-khol, mustard, *asalio* (*Lepidium sativum*), *mogari* (*Raphanus sativus* var. *caudatus*) and *rai* (*Brassica juncea*). The attacked leaves show prominent brown veins which when extensive bring about withering of the leaves. Such infected plants, if stripped, show dark brown bundles full of bacterial ooze. In the later stages of the disease, many saprophytic organisms get in and bring about rotting and softness of the cabbage heads. It has been shown that the noticeable symptoms require 2 to 3 weeks from the time of infection in the seed-bed with crowded seedlings.

Organisms isolated from young freshly infected leaves of cabbage, cauliflower, knol-khol and radish, have been found to be similar in morphology, physiology and pathogenicity and therefore it is presumed that *Xanthomonas compestris* (Pammel) Dowson is responsible for infection in these 4 hosts besides mustard, *mogari, rai*, turnip and *asalio* but not *Nasturtium*. A short description of the pathogene as found by us is as follows :—

The organism is a short rod with rounded ends, occurring singly, rarely in pairs. In culture on potato dextrose agar varying in age from 1 to 3 weeks it measures 1.54μ (1.17—2.07μ) x 0.72μ (0.54—0.99μ). Motile with a single polar flagellum, gram-negative, not acid fast, capsulated, without spore formation.

On potato dextrose agar plates the colonies are circular, smooth, glistening, convex with entire margin measuring 1 cm. in 4 days, with no striations, colour amber-yellow (Ridgway) but there is no distinctive odour ; gelatin liquefied ; starch attacked ; casein digested ; hydrogen sulphide not produced ; litmus reduced ; nitrates not reduced ; indol and ammonia not produced ; acid but no gas in dextrose, lactose and mannitol ; no growth in Cohn's but fair growth in Uschinsky's solutions; tolerant to 4 per cent sodium chloride. The organism does not grow in salicin nor utilises asparagin and l. arabinose. Thermal death point about 50° C.

In order to find if there exists any varietal resistance in the hosts, the following varieties of cabbage, turnip and radish were inoculated and found to be equally susceptible.

Host		Varieties	Infection	Remarks (Source of seed)
Cabbage	1.	Savoy (Drum Head)	+	Suttons, Calcutta
	2.	Sutton's Flower of Spring	+	,,
	3.	Sutton's Pride of India	+	,,
	4.	Sutton's Eclipse Drumhead	+	,,
	5.	Sutton's Earliest Cabbage	+	,,
	6.	Chinese Cabbage Petasi	+	,,
	7.	Glory of Enkhuizen	+	L. R. Brothers
	8.	Golden Acre	+	Saharanpur, U. P.
	9.	Copenhegan Market	+	,,
	10.	Charleston	+	,,
Turnip	1.	Sutton's Early White Milan	+	Suttons
	2.	Golden Ball	+	,,
	3.	Purple Top White	+	,,
	4.	Sutton's Early Snow-ball	+	,,
	5.	Red Stone	+	L. R. Brothers
Radish	1.	Sutton's Red White Tipped	+	Suttons
	2.	Long Scarlet	+	,,
	3.	Scarlet Globe	+	,,
	4.	French Breakfast	+	L. R. Brothers
	5.	Sparkler	+	,,
	6.	Long Scarlet	+	,,
	7.	Red Turnip White-tipped	+	,,

Control Measures

Spraying of the crop in the field has not been found to be of any use, as the infection is confined to vascular bundles.

Disinfecting the seed with corrosive sublimate (1 : 1000) for 30 minutes has given encouraging results but this cannot be considered a completely successful treatment as corrosive sublimate kills bacterial organisms external on the seed-cost, whereas the organisms inside the seed-coat remain unaffected causing fresh infection in the new crop. For this purpose, treating the seeds in hot water at 122° F. for 30 minutes to kill all the orgnisms is the best methcd. But this treatment requires skill and accuracy on the part of the worker.

A new method of disinfecting seeds in bleaching powder solution (10 per cent) for 4 hours has given fairly good results.

Treating the seed is not the final solution of the problem as primary and secondary infections may start from soil harbouring infected plant roots or infected plant debris of the previous season. Care should, therefore, be taken to raise seedlings in a seed-bed not previously under a diseased crop ; if a disease-free plot be not available, heating the seed-bed by rabbing as is done in the case of rice seed-beds could be resorted to. Drenching the seed-bed with 5 per cent commercial formalin has its advantages.

Thin sowing in seed-beds is particularly advocated since it allows more light, decreases humidity thus checking indirectly the spread of the disease.

Use of seed from disease-free locality is advantageous as it saves the expense and labour of disinfecting the seeds.

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NITROGEN UTILIZATION BY XANTHOMONAS MALVACEARUM (SM.) DOWSON

By M. K. PATEL AND Y. S. KULKARNI

(Accepted for publication April 3, 1949)

MICROORGANISMS are, as a rule, unable to grow in artificial culture media without the presence of suitable nitrogen compounds. A large number of them do not show any discriminating tendency in their use of such compounds but there are certain others which are specific in their requirements. Thus, Fellows (1936) pointed out that *Ophiobolus graminis* Sacc. failed to grow on some of the inorganic and organic nitrogen compounds that he used in his experiments, whereas it grew well on egg albumen, casein and peptone. Ostroff and Henry as quoted by ZoBell (1946) have shown that all the 15 representative aerobic bacteria of marine origin were able to utilise peptone ; only 8 could utilise asperagine while only five could utilise di-ammonium phosphate as a source of nitrogen.

The work on the nutritional requirements of microorganisms has, mostly, been confined to saprophytic fungi but very scanty attention has been paid to fungous parasites and still less to the phytopathogenic bacteria. The work herein reported was undertaken to determine the source of nitrogen utilised by *Xanthomonas malvacearum*, the parasite infecting exotic and Indian cottons, along with five parasitic fungi *viz. Actinodochium* sp. on mango fruit, *Helminthosporium sativum*, *Fusarium vasinfectum* from cotton, *Fusarium udum* from pigeon pea, *Fusarium orthoceras* from *Lathyrus sativus* and two saprophytes *viz. Aspergillus niger* and *Penicillium* sp.

The nitrogen compounds that were used in these tests were chemically as pure as could be obtained from the manufacturers (B. D. H.). The organic and inorganic compounds whose atomic weights are definitely known were utilised in the experiments thus maintaining a definite amount of elemental nitrogen. The experiments were carried out with 1% and 0.14% nitrogen taking the Richard's medium as standard, which contained 10 gms. of KNO_3 in 1000 c.c. solution or 1 gm. in 100 c.c., that is, 14 parts of nitrogen in 101 parts (atomic weight of KNO_3) or the liquid or 0.14 % N Accordingly the amounts of different compounds were determined for 1% and 0.14% nitrogen, for instance, 0.32 gm. of urea (NH_2CONH_2), 2.6 gm. of Uranium nitrate. $UO_2(NO_3)_2 . 6H_2O$ in 100 c.c of the liquid for 0.14 % of nitrogen.

The standard Richard's liquid medium without KNO_3 was used as a base, to which required amount of different nitrogen compounds was added. The hydrogen-ion concentration was adjusted approximately to 7 pH by using Brom Thymol Blue as an indicator. Test tubes were filled with 10 c.c. of the liquid and sterilised at 15 lbs. pressure for 15 minutes after which, these were inoculated by the organism, (48 hours old) incubated at 26-30° C. for 3-7 days after which the results were recorded on the basis of relative abundance of growth rated by symbols 0, 1, 2, 3 and 4. The results presented in the following table represent the average of two trials for 1% nitrogen and an average of 4 trials for 0.14% nitrogen.

It will be noted from the Table that the nitrogen compounds such as nitrates of aniline, cadmium, cerium, chromium, cobalt, copper, iron, lead, nickel, silver, thorium and uranium and sodium nitrite are lethal not only to *X. malvacearum* but also to other saprophytic and parasitic fungi. It is a well known fact that silver, copper, arsenic and sodium nitrite are poisonous. The nitrogen compounds containing aniline, cadmium, cerium, iron and lead are toxic to microoganisms as has also been shown by Martin (1940). Porter (1947) has noted that chromium, nickel and thorium are poisonous beyond 100 p.m.

All the organisms except *Aspergillus niger* failed to grow in compounds containing aluminium and zinc. Martin (1940) has recorded the fungicidal value of zinc compounds while Calvery (1942) as quoted by Porter (1947) has found that aluminium is toxic to microorganisms beyond 100 p.p.m.

On amyl nitrate, creatine and barium nitrate, *Xanthomonas malvacearum* failed to grow while the others showed very poor growth proving that these are also toxic.

Nitrate of calcium, ethyl, magnesium, sodium, strontium and urea, ammonium bicarbonate, ammonium chloride, ammodium lactate, ammonium oxalate, ammonium phosphate, ammonium tartrate, ammonium thiocyanate permit good growth of all the organisms except *Xanthomonas malvacearum*.

The rest of the nitrogen compounds, *viz.*, potassium nitrate, ammonium citrate, ammonium nitrate and ammonium sulphate of the inorganic group and asparagin and uric acid of the organic group allow all the organisms to grow luxuriantly.

Xanthomonas malvacearum appears to be highly specific in its nitrogen requirements as it can be seen that the growth occurs in only 6 out of 38 nitrogen compounds that were used. Our results, as far as this organism is concerned, are in perfect agreement with those of Lewis (1930) who has shown that this organism grows well in ammonium citrate, asparagin and uric acid but fails to grow in ammonium oxalate and ammonium tartrate. It may also be noted that the source of nitrogen is not the only factor in the growth of microorganisms but that the source of carbon is also as important as has been shown by Lewis (1930).

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TABLE I

Relative growth of Xanthomonas malvacearum *and other fungi in relation to utilisation of nitrogen from different sources*

Source of nitrogen	*Xantho-monas malva-cearum*		*Actinodo-chium* sp.		*Helminthos-porium sativum*		*Fusarium vasinfectum (cotton)*		*F. udum* (pigeon pea)		*F. orthoceras (Lathyrus sativus)*		*Penicillum* sp.		*Aspergillus niger*	
	1 %	0.14%	1 %	0.14%	1 %	0.14%	1 %	0.14%	1 %	0.14%	1 %	0.14%	1 %	0.14%	1 %	0.14%
1. Aniline nitrate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2. Cadmium ,,	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2. Cerium ,,	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4. Chromium ,,	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5. Cobalt ,,	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6. Copper ,,	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7. Ferric ,,	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8. Lead ,,	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9. Nickel ,,	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10. Silver ,,	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11. Thorium ,,	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12. Uranium ,,	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13. Sodium nitrite	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14. Ammonium alum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
15. Zinc nitrate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
16. Aluminium nitrate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
17. Amyl nitrate	0	0	0	2	0	4	0	2	0	2	0	1	0	2	0	2
18. Barium nitrate	0	0	0	2	0	1	0	1	0	2	0	1	0	3	0	2
19. Creatine	0	0	1	1	1	1	1	1	1	1	1	1	0	4	1	1
20. Ammonium bicarbonate	0	0	0	4	0	3	0	4	0	4	0	3	0	4	0	3
21. Calcium nitrate	0	0	0	3	0	4	0	4	0	4	0	4	0	4	3	4
22. Ethui ,,	0	0	0	2	0	4	0	4	0	2	0	2	0	3	3	3
23. Magnesium ,,	0	0	2	2	2	4	2	4	2	4	0	4	0	4	3	3
24. Sodium ,,	0	0	1	2	0	4	2	4	2	2	3	3	0	4	3	3
25. Strontium ,,	0	0	0	4	0	1	0	4	0	4	0	4	0	4	0	4
26. Urea	0	0	0	4	0	3	0	4	0	4	0	4	0	4	2	4
27. Ammonium chloride	0	0	1	4	1	4	2	4	2	4	2	4	0	4	3	4
28. ,, lactate	0	0	3	4	2	4	4	4	3	4	4	4	0	4	4	4
29. ,, oxalate	0	0	0	3	1	4	1	4	1	4	1	4	0	4	4	4
30. ,, phosphate	0	0	1	1	0	4	4	4	3	4	2	3	0	4	0	4
31. ,, tartrate	0	0	2	3	2	3	4	4	4	4	4	4	0	4	4	4
32. ,, thiocyanate	0	0	0	3	2	3	1	4	0	2	1	2	0	4	2	4
33. ,, citrate	0	4	0	4	1	4	2	4	2	3	1	4	0	4	4	4
34. ,, nitrate	0	4	2	3	2	4	4	4	3	3	4	4	9	4	4	
35. ,, sulphate	0	3	0	3	2	4	4	4	3	4	4	4	0	4	4	4
36. Potassium nitrate	0	4	0	3	0	4	4	3	4	3	0	3	0	3	1	3
37. Asparagin	0	4	2	3	4	4	4	4	4	4	4	4	0	4	4	4
38. Uric acid	2	3	2	4	1	3	4	4	2	4	2	3	0	4	3	3

0..No growth 1..Slight growth 2..Fair growth 3..Good growth 4..Heavy growth

GENERA OF RUSTS I

BY M. J. THIRUMALACHAR AND B. B. MUNDKUR

(Accepted for publication, April 4, 1949)

THE Uredinales or plant rusts form an important group of plant pathogens with world-wide distribution. Their study has made rapid progress due to outstanding contributions by Urediniologists from several European countries, U. S. A., and Canada. Tropical America has provided abundant material to indefatigable collectors and the accounts of numerous new rust genera have broadened our concept of the range of variation with in them.

The literature on Uredinales is, however, scattered. The four volumes of "Monographia Uredinearum" by H. & P. Sydow published between 1902-1924 contain a wealth of information, and so does Dietel's treatise in Engler and Prantl's "Die natürlichen Pflanzenfamilien" published in 1928. Nearly twenty three years have since elapsed, during which time considerable advances in our knowledge of tropical rusts have been made. In this series of papers the authors plan to bring together as much of the available information as is possible.

Much of the information on rust genera had been collected by the second author during the past several years, based on an examination of specimens kindly sent by Arthur, Arwidsson, Cummins, Dietel, Mayor, Whetzel and others and the senior author had recently the unique opportunity of examining types and representatives of several genera in the Arthur Herbarium and the Herbaria of the following institutions: U. S. Dept of Agriculture, Pennsylvania State College, University of Wisconsin, University of Michigan and the Royal Botanic Garden, Kew, England. The authors desire to place before other Urediniologists the material so accumulated for critical examination.

The results of these studies will be first published in this Journal and it is proposed to publish them later in the form of a loose-leaf book. The co-operation of Mycologists and Plant Pathologists in this endeavour is earnestly requested and they are invited to send critical comments and suggestions.

The authors wish, finally, to express their indebtedness to Dr G. R. Bisby, Dr G. B. Cummins and Dr F. D. Kern for advice and help on numerous occasions. They are especially grateful to Dr Cummins for enlightening them on several aspects of the probelm, but they are alone responsible for the opinions and observations made on several of the genera and their relationships.

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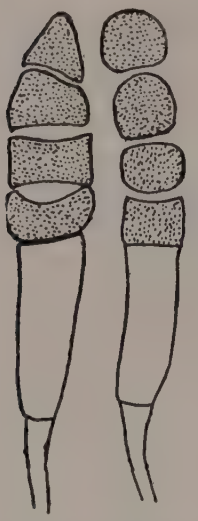


Fig. 1. Acervulospora

1. **ACERVULOPSORA** Thirumalachar in *Mycologia* **37**, p. 299, 1945. Fig. 1.

Pycnia and aecia unknown. Uredia subepidermal; urediospores borne on pedicels. Telia subepidermal, erumpent, acervulus-like; teliospores clavate, hyaline, thin-walled, germinating intra-sorum at maturity by the prolongation of spore-apex. Promycelium semi-internal (including the upper portion of the teliospore), 4-celled; sporidia formed by the rounding up of the promycelial cells.

TYPE SPECIES: *Acervulopsora ichnocarpi* (Barclay) Thirumalachar on *Ichnocarpus frutescens* (Apocynaceae)

DISTRIBUTION: India (single species)

NOTES.—Only uredia and telia are known. Sydow (1928) has established the genus *Achrotelium* on another species of the host genus, *Ichnocarpus*, from the Philippines. The teliospores of *Acervulopsora* differ from those of *Achrotelium* in their type of germination. In the latter the promycelium is internal whereas in *Acervulopsora*, the teliospores at first germinate by the prolongation of the spore-apex but the promycelium is semi-internal. There is a resemblance to *Maravalia* whose promycelium is also produced by the prolongation of the spore-apex but it is, however, external. In having semi-internal promycelium, *Acervulopsora* resembles *Cystopsora* and *Zaghouania*. The fragile type of promycelium whose cells round off into sporidia, which is found in *Acervulopsora*, is also met with in *Chrysocelis muehlenbackiae* Lagerh. & Diet. (Dietel, 1914).

Dietel, P. (1914) .. .. .. *Ann. Mycol.* **12**: 83-88

Sydow, H. and Perak, F. (1928) .. *Ann. Mycol.* **26**: 425

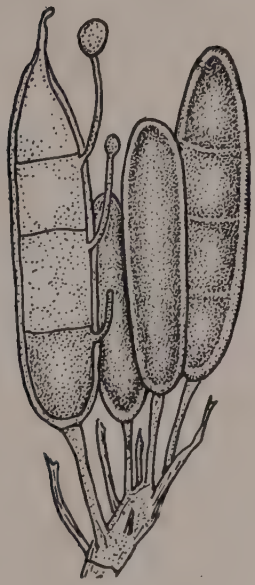


Fig. 2. Achrotelium

2. **ACHROTELIUM** Sydow in *Ann. Mycol.* **26**, p. 425, 1928. Fig. 2.

Pycnia subcuticular. Aecia (= primary uredia) uredinoid, similar to uredia that follow. Uredia subepidermal, aparaphysate, erumpent, minute ; urediospores oval or ellipsoidal, borne on pedicels. Telia subepidermal, erumpent, pale yellow, slightly waxy ; teliospores 1-celled, borne singly or in groups on sporogenous basal, cells, hyaline or slightly tinted, cylindrical, with hyaline wall, slightly hygroscopic, germinating at once by the formation of 4-celled internal promycelium ; sporidia borne on short sterigmata.

TYPE SPECIES : *Achrotelium ichnocarpi* Syd. on *Ichnocarpus volubilis*, (Apocynaceæ)

DISTRIBUTION : India, Philippines, and South America (3 species)

NOTES : As pointed out by Arthur and Cummins (1936), the telia of *Achrotelium* superficially resemble those of *Maravalia* but the manner of germination by an internal promycelium distinguishes this genus sharply from it. The absence of a gelatinous matrix embedding the teliospores separates it from *Goplana* which also develops an internal 4-celled promycelium. Similar type of germination is seen in *Chrysella* but Sydow (1928) states that the teliospores shrink after germination in *Chrysella* but retain their shape and remain firm in *Achrotelium*. These, however, are hardly characters of importance to separate the two genera but they can be distinguished on the basis of pycnial characters, being subcuticular in *Achrotelium* and subepidermal in *Chrysella*.

Arthur, J. C. and Cummins G. B. (1936) .. .. *Phillip. J. Sci.* **61** : 478
Cummins, G. B. (1940) .. .. *Bull. Torrey Bot. Cl.* **67** : 68

3. **AECIDIUM** Persoon [in *Gmel Syst. Nat.* **2**, p. 1472, 1791.] Syn. Meth. Fung. p. 204, 1801.

Syn. *Monosporidium* Barclay in *J. Asiatic Soc. Bengal* **56**, p. 367, 1887.

Pycnia subepidermal, flask-shaped, rarely subcuticular, usually with ostiolar paraphyses. Aecia at first immersed, closed, cylindrical or urceolate, dehiscent at apex,

firm or evanascent, not infrequently causing more or less hypertrophy of the affected parts. Peridium usually well developed, 1-celled, thick, white or yellowish with entire, incised or lacerate margin ; erect or revolute. Spores arising in catenulations from the hymenium at the base of aecial cup, angularly globoid with smooth, verrucose or echinulate wall.

TYPE SPECIES : Genus based on a *concept* and not a type species. *A berberidis* Pers. was chosen as lectotype by Clements and Shear.

DISTRIBUTION : Wide. Several species.

NOTES : This form—genus includes those species whose perfect state, *viz.*, telia, are unknown. In *Aecidium* on two species of *Euphorbia* and two of *Andrachne*, Barclay (1887) noted the formation of a single sporidium-like structure at the apex of the germ tube without any sterigmata. He therefore established this genus *Monosporidium* with two species for accomodating those rusts. Sydows (1924) have recognised the genus though Dietel (1928) has reduced it to synonymy. There is no indication of a promycelium-like structure in the germinating spore. Aeciospores of *Uromyces hobsoni* also germinate by a 1-septate germ tube and both the cells develop whip-like branches which appear to have been misconstrued by Barclay and others as sterigmata formed from a 2-celled promycelium. Thirumalachar (1939) has shown this to be of the nature of an appressorium penetrating the host. In the absence of further studies, *Monosporidium* may be treated as a synonym of *Aecidium*.

Arthur, J. C. (1934) .. Manual of Rusts. p. 380
Clements F. E. & Shear, C. L. (1931). Genera of Fungi. p. 334
Dietel, P. (1928) .. .. Die natürlichen Pflanzenfamilien **6** : 97
Doidge, E. M. (1926) .. *Bothalia* **2** : 167.
Sydow, P. & H. (1924) .. Monogr. Ured. **4** : 364-365
Thirumalachar, M. J. (1939) *Phytopathology* **29** : 783-792

4. **ALLOTELIUM** Sydow in *Ann. Mycol.* **37**, p. 312-313, 1939

Pycnia, aecia and uredia unknown. Telia subepidermal, covered by coloured, cellular, multilayered, persistent peridia ; teliospores binate, laterally united, two cells of the spore being borne at apex of the simple pedicel ; epispore hyaline or slightly coloured ; germ pores equatorial

TYPE SPECIES : *Allotelium mirabile* Syd. on *Calliandra trinerva* Benth.

DISTRIBUTION : Ecuador, (single species)

NOTES : No specimens of the rust are available for examination as Sydow's Herbarium is believed to have been destroyed at the time of bombing of Berlin. The above description is taken from Sydow (1939). The teliospores are binate as in *Diorchidium* and the sori are bordered by a multilayered persistent peridium.

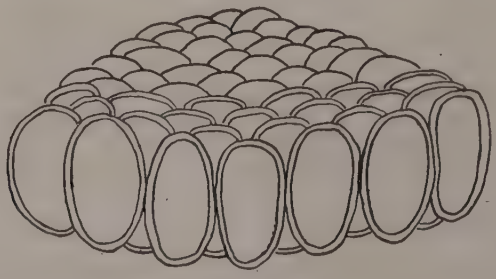


Fig. 3, Alveolaria

5. **ALVEOLARIA** Lagerheim in *ber. dtsch. bot. Ges.* **9**, p. 346, 1892. Fig. 3.

Pycnia subepidermal, immersed, with ostiolar paraphyses. Aecia and uredia unknown. Telia subepidermal, erumpent, without peridium, developing teliospores in short cylindric columns ; teliospores ovoid or prismatic, 1-celled, forming detachable transverse layers, thin-walled, germinating immediately at maturity. Promycelium external and 4-celled.

TYPE SPECIES : *Alveolaria cordiae* Lagerh. on *Cordia* sp.(Boraginaceæ)
DISTRIBUTION : South America (3 species)

NOTES : Of the 3 species so far described, both *Alveolaria cordiae* and *Alveolaria andina* are on species of *Cordia*. *Alveolaria duguetiæ* was described by Viegas (1945) from Brazil on *Duguetia furfuracea*, a member of the Anonaceæ. Pycnia were for the first time described by him. Teliospores form short columns adhering more laterally than vertically. The columns break up into circular plates of 1-celled thickness. The mode of separation of these circular plates from the column superficially resembles the banana splits. In consequence of this peculiar mode of separation of the telial columns into one layered spore plates, the genus occupies an isolated position in the Uredinales.

Arthur J. C. (1907) .. .. N. Amer. Fl. **7** : 124
Clements, F. and Shear, C. L. (1931). The Genera of Fungi, p. 334
Dietel, P. (1928) .. .. Die natürlichen Pflanzenfamilien **6** : 94
Sydow, P. and H. (1915) .. Monogr. Ured. **3** : 551
Viegas, A. P. (1945) .. *Bragantia* **5** : 9-10

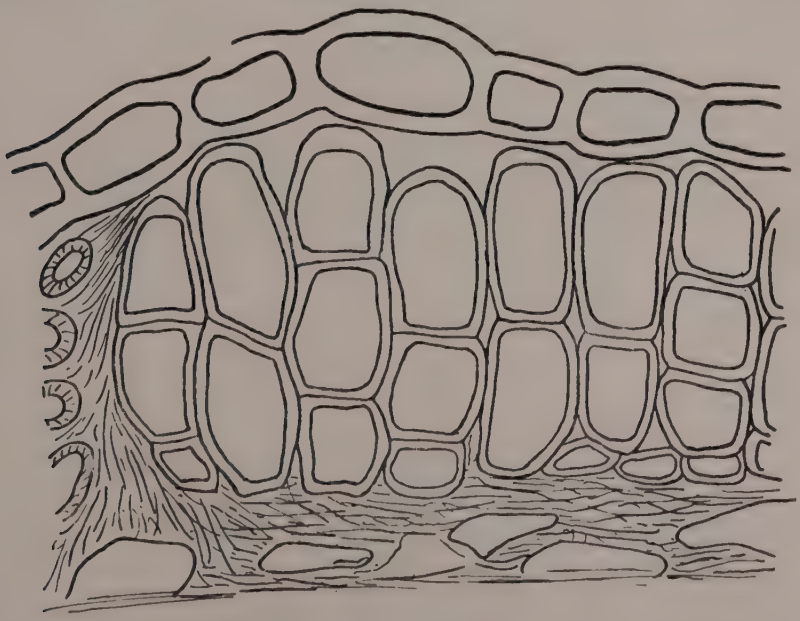


Fig. 4. Angiopsora

6. **ANGIOPSORA** Mains in *Mycologia* **26**, p. 126, 1934. Fig. 4.

Pycnia and aecia unknown. Uredia subepidermal, minute, lined with incurved paraphyses borne on hyphoid peridium ; urediospores without conspicuous pedicels.

Telia subepidermal in non-erumpent lenticular crusts; teliospores catenulate, produced in basipetal succession in chains of 2 to 8 spores; adhering both laterally and vertically to form a compact crust, reddish-brown in colour with firm walls.

TYPE SPECIES : *Angiopsora lenticularis* Mains on *Lasciacis ruscifolia* (Gramineæ)
DISTRIBUTION : Wide spread, specially in tropical America. (Several species)

NOTES : The genus is established for accomodating those species of rusts which have phakopsoroid uredia and telia but the teliospores of which, however, develop in chains from the basal hymenium. Uredia possess characteristic incurved paraphyses surrounding the sorus and are developed from hyphoid peridium in some cases. The paraphysate nature of the uredia distinguishes *Phakopsora* and *Angiopsora* from *Bubakia*.

The telia are subepidermal, non-erumpent and lenticular and the teliospores are formed successively in chains from the basal hymenium. The telial chains are sessile and adhere both vertically and laterally to form a compact crust. This catenulate condition separates *Angiopsora* both from *Phakopsora* and *Bubakia* where the teliospores are developed in irregular succession, the younger alternating with the older, and wedging in between them to form a compact crust. A concise key for distinguishing some of these closely related genera is given by Thirumalachar and Kern (1949).

The enumeration of several species of *Angiopsora* by Mains on graminicolous hosts led to the view that the genus is restricted to Gramineæ while *Phakopsora* occurred on Dicotyledons. But Thirumalachar and Kern (1949) have shown that several species reported as *Phakopsora* on dicots are in fact *Angiopsora*. Cummins has described species of *Phakopsora* on grasses so that there is no restriction of hosts.

Angiopsora divina described by Sydow on giant bamboo has been placed under a new genus, *Dasturella*, by Mundkur and Kheswalla, since the telia are erumpent and flabelliform.

Mundkur, B. B. and Kheswalla, K. F. (1943). *Mycologia* **35** : 201
Sydow, H. (1936) .. .. *Ann. Mycol.* **34** : 69-73
Thirumalachar, M. J. and Kern F. D. (1949) *Mycologia* **41** : 283-290

Fig. 5 Anthomyces

7. **ANTHOMYCES** Dietel in *Hedwigia*, **38**, p. 253, 1899. Fig. 5.

Pycnia and aecia unknown. Uredia and telia minute, paraphysate and punctiform ; urediospores formed on thin pedicel-hyphæ and provided with numerous germ pores. Teliospores as egg-shaped to globose heads consisting of three to many

coalesced spore-cells. Pedicel simple ; small sterile cells that do not swell in water occur between the pedicel and heads.

TYPE SPECIES : *Anthomyces brasiliensis* Dietel on Leguminosæ

DISTRIBUTION : Brazil (single species)

NOTES : Paraphyses are coalescent at the base and free at the apex. Teliospores germinate at maturity forming 4-celled promycelium. Dietel compares this genus with *Ravenelia* and *Sphaerophragmium*. He considers that the sterile cells which do not swell in water between the base of the teliospore heads and the pedicel are comparable to the cysts. They are not biologically same as cysts, as they do not have gelatinous contents. The occurrence of the simple pedicel in *Anthomyces* separates it from *Ravenelia* and the mode of spore arrangement in the telial head from *Sphaerophragmium*.

The structure of the telial head resembles that of *Dicheirinia*. The teliospores in that genus are united laterally, subtended by basal cells (apical cells of pedicels according to Cummins) which are borne on a simple pedicel. The same characters are duplicated in *Anthomyces* and the sterile cells between the pedicel and the telial head are in fact apical cells of the pedicel. The teliospores in *Dicheirinia*, so far known, are tuberculate or covered with digitately lobed processes, while those of *Anthomyces* are smooth. In the absence of precise knowledge of the pycnial and aecial stages of *Anthomyces*, it is not possible to institute further comparisons.

Dietel, P. (1928) .. .. Die natürlichen Pflanzenfamilien **6** : 70

Sydow, P. & H. (1915) .. Monogr. Ured. **3** : 89

Fig. 6. Anthomycetella

8. **ANTHOMYCETELLA** H. & P. Sydow in *Ann. Mycol.* **14**, p. 353, 1916, emend. Fig. 6.

Syn. *Reyesiella* Sacc. *Atti dell'Acad. Veneto-Trentino-Istriana* **10**, p. 58, 1917.

Pycnia, aecia and uredia unknown. Urediospores intermixed with telia, without distinct germ pores. Telia superstomal, formed above the epidermis on columnar strands of hyphæ pushing through the stomata, surrounded by incurved marginal paraphyses ; teliospores in heads surrounded by a brownish-yellow, gelatinous membrane ; spores formed in compact clusters, successively at the apex of 2 to 4 closely grouped basal cells, firmly held by the outer spore membrane. Mature spores clavate, cylindric, germinating immediately at maturity. Pedicels compound, hyphæ corresponding to the number of basal cells.

TYPE SPECIES : *Anthomycetella canarii* Sydow on *Canarium villosum* (Burseraceæ)

DISTRIBUTION : Philippines (single species)

NOTES : Sydows described the telial heads borne on compound pedicels of 3 to 4 hyphal strands. The teliospores were stated to be arranged in two tiers, the upper having a larger number of spores than the lower. The genus was differentiated from *Anthomyces* in the possession of compound pedicels and lack of cyst-like cells.

In a restudy of the *cotype* of the genus, Thirumalachar (1947) traced the developmental stages of the telial head. The teliospores are one-layered and developed from sporogenous basal cells and both these are enveloped by a gelatinous membrane. In a developing sporehead, therefore, the teliospores are of different maturity, the marginal ones being the youngest. Urediospores associated with the telia were seen by Thirumalachar.

Dietel, P. (1928) .. .. Die natürlichen Pflanzenfamilien **6** : 70
Thirumalachar, M. J. (1947) *Mycologia* **39** : 334-340

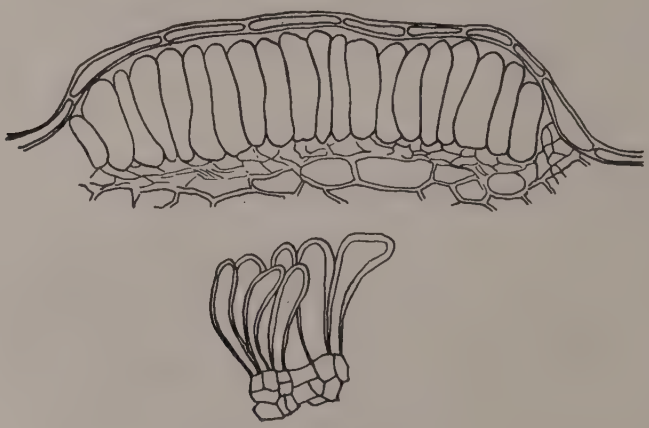


Fig. 7. Aplopsora

9. **APLOPSORA** Mains in *Amer. J. Bot.* 8, p. 442, 1921. Fig. 7.

Pycnia and aecia unknown. Uredia subepidermal, pulverulent, becoming naked, surrounded by a peripheral incurved paraphyses arising from small-celled, inconspicuous pseudoperidium united below ; urediospores sessile, echinulate ; germ pores obscure or none. Telia lenticular at first, soon erumpent, becoming naked, in small groups, cinerous from germination ; teliospores 1-celled, cylindric, in one layer, thin-walled, colourless, smooth, germinating immediately after reaching full size by apical promycelium.

TYPE SPECIES : *Aplopsora nyssæ* (Ell. & Tracy) Mains on *Nyssa aquatica* (Nyssaceae)

DISTRIBUTION : North America (single species)

NOTES : The structure of the uredia with its incurved paraphyses developing from a peridial layer and sessile urediospores place this genus near *Phakopsora* and *Cerotelium*. Telia are erumpent and composed of 1–layered, hyaline spores. The structure of the uredium and the telium separates it from *Melampsora* which possesses non-erumpent, coloured telial crusts. Hyaline teliospores occurring in crusts and germinating immediately are also met with in *Chnoopsora*. In that genus the teliospores are successively formed from the basal hymenium, the younger spores wedging between the older ones. On the contrary, in *Aplopsora*, the teliospores occur in a single layered crust.

Arthur, J. C. (1934) .. .. Manual of Rusts, p. 59
Clements, F. E. and Shear, C. L. (1931) The Genera of Fungi, p. 148, 334
Dietel, P. (1923) .. .. *Ann. Mycol.* **21** : 84-86
Dietel, P. (1928) .. .. Die natürlichen Pflanzenfamilien **6** : 56

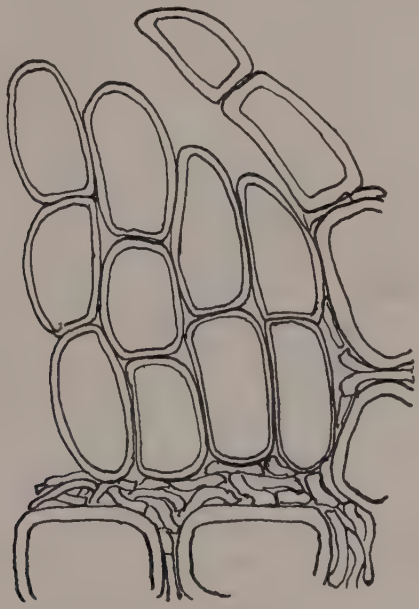


Fig. 8. Arthuria

10. **ARTHURIA** Jackson in *Mycologia* **23,** p. 463, 1931. Fig. 8.

Pycnia subcuticular, other sori subepidermal. Aecia caeomoid ; aeciospores catenulate, echinulate. Uredia like aecia, with catenulate urediospores and sterile intercalary cells. Telia semi-waxy; teliospores catenulate, thin-walled, germinating immediately at maturity.

TYPE-SPECIES : *Arthuria catenulata* Jackson and Holway on *Croton* sp. (Euphorbiaceæ)

DISTRIBUTION : Brazil and probably other South American countries (2 species)

NOTES : Only two species are known and both of them are on *Croton* sp. Structure of the uredia and telia somewhat resembles *Chrysomyxa* but the pycnia are subcuticular and aecia cæomoid in contrast to the subepidermal pycnia and peridiate aecia of *Chrysomyxa*. In early stages the telia are non-erumpent and lenticular and resemble those of *Phakopsora*. However the mature telia are erumpent which they are not in *Phakopsora*. Teliospores also are hyaline and germinate immediately after maturity, a feature lacking in *Phakopsora*. The telia somewhat resembles *Cerotelium* in that the teliospores occur in chains of 1-celled hyaline spores, coalesced laterally to form a waxy crust. But the uredia differ in the two genera, being caeomoid in

Arthuria and phakopsoroid in *Cerotelium*. A key to the genera is given by Thirumalachar and Kern.

Cummins, G. B. (1943) .. *Bull. Torrey Bot. Cl.* **70**: 517-530.

Thirumalachar, M. J. and Kern, F. D. (1949). *Mycologia* **41**: 283-290.

Fig. 9. Atelocauda

11. **ATELOCAUDA** Arthur and Cummins in *Ann. Mycol.* **31**, p. 41, 1933. Fig. 9.

Pycnia subcuticular without conspicuous paraphyses. Aecia and uredia unknown. Telia subepidermal; teliospores unicellular, pedicellate (or produced singly at the apex of pedicels); epispore coloured, provided at the apex with a single germpore.

TYPE SPECIES: *Atelocauda incrustans* Arthur & Cummins on *Lonchocarpus* sp. (Leguminosæ)

DISTRIBUTION: PANAMA (single species)

NOTES: In general appearance this genus resembles *Uromyces* but the pycnia are subcuticular. The teliospore markings resemble those of *Dicheirinia* and *Diabole*, being irregular cubical or with digitate warts. But the teliospores are borne singly on the pedicels in *Atelocauda*. Cummins (1937) states that *Atelocauda incrustans* might with considerable justification be considered as directly derived from *Dicheirinia* by continued simplification. Since the teliospores are reduced to single cells, it would seem logical that the pedicels also should become unicellular structures. It may be pointed out that *Atelocauda* lacks apical cells of pedicels, so characteristic of *Dicheirinia*. Mundkur and Thirumalachar have pointed out that *Trachyspora* shows the same teliospore markings and the apical cell of the pedicel as in *Dicheirinia* but it is 1-celled. Its pycnial stage is unknown and hence further comparisons with *Atelocauda* cannot be made.

Cummins, G. B. (1937). .. *Bull. Torrey Bot. Cl.* **64**: 41

Mundkur, B. B. and Thirumalachar, M. J. (1946). *Mycol. Pap. Imp. Mycol. Inst.* **16**: 13

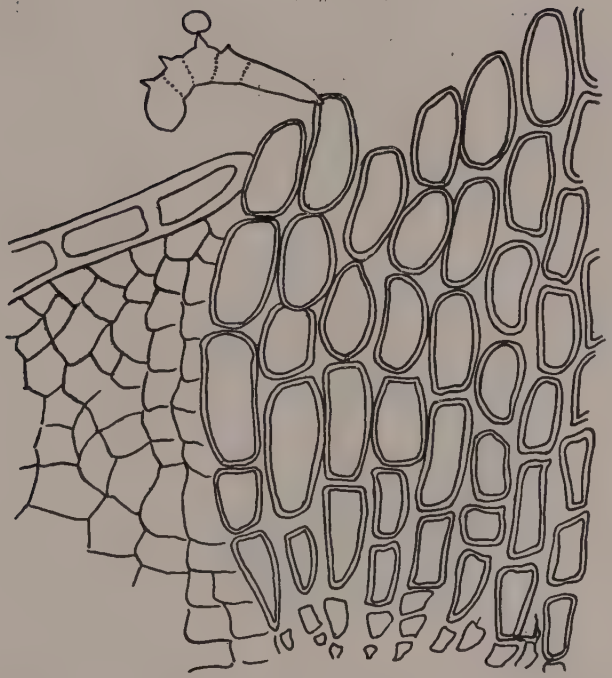


Fig. 10. Baeodromus

12. **BAEODROMUS** Arthur in *Ann. Mycol.* **3,** p. 19, 1905. Fig. 10.

Pycnia subepidermal, deep seated, flask-shaped or globose, without conspicuous ostiolar paraphyses. Aecia and uredia unknown. Telia subepidermal, erumpent, minute, compact, without peridia ; teliospores catenulate, ellipsoid to oblong, 1-celled, hyaline, or slightly coloured, smooth, germinating at maturity by a 4-celled external promycelium with globose sporidia.

TYPE SPECIES : *Beodromus holwayii* Arthur on *Senecio cinerarioides* (Compositae)

DISTRIBUTION : North and South America. (5 species).

NOTES : Arthur described four species on the genera *Senecio* and *Eupatorium* of Compositæ. Thirumalachar and Kern (1949) have found that the rust described as *Phakopsora dominicana* Kern on *Croton* (Euphorbiaceæ) is also a species of *Beodromus*. Telia are deep seated and the teliospores are produced in chains. The teliospores are thick-walled and slightly coloured but there is no resemblance with *Endophyllum*. The telia are erumpent and appear as crusts but are not flabelliform as in *Dasturella*. There is some resemblance to *Dietelia* but as that genus has peridiate telia it differs from *Beodromus*.

Arthur, J. C. (1907) .. .. N. Amer. Fl. **8** : 125

Arthur, J. C. (1934) .. .. Manual of Rusts, p. 62

Dietel, P. (1928) .. .. Die natürlichen Pflanzenfamilien **6** : 94

Sydow, P. & H. (1915) .. Monogr. Ured. III, p. 548

Thirumalachar, M. J. and Kern, F. D. (1949). *Mycologia* **41** : 283-290.

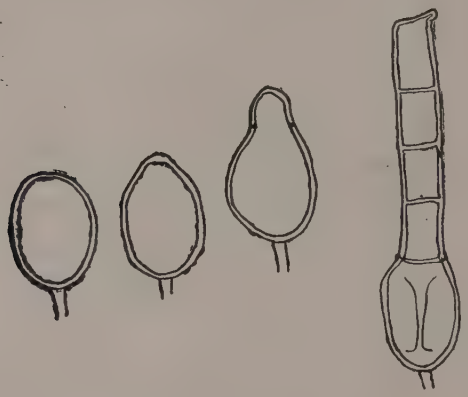


Fig 11. Blastospora

13. **BLASTOSPORA** Dietel in *Ann. Mycol.* 6, p. 222, 1908. Fig. 11.

Pycnia and aecia unknown. Uredia superstomal (possibly also subepidermal), spore-bearing cells forming a small compact group above the stoma from mycelium emerging from it ; urediospores obovoid, or ellipsoid, echinulate, pedicellate. Telia superstomal, spore-bearing cells forming a small compact group above the stoma from the mycelium emerging from it ; teliospores globoid or ovoid, wall thin, hyaline, pedicellate, germinating at once ; the wall of the teliospore apparently not continuing as the wall of the promycelium.

TYPE SPECIES : *Blastospora smilacis* Dietel on *Smilax sieboldi* Miq. (Liliaceæ)

DISTRIBUTION : Japan (2 species)

NOTES : Both the species parasitise species of *Smilax* in Japan. Telia are minute and superstomal, thereby showing relationship with the Hemileiæ of Dietel's classification rather than Eriosporangiæ. There are no germ pores in the teliospores and the promycelium is separated from the empty germinated teliospore by a convex wall. Mains stresses relationship between *Blastospora*, *Hemileia* and *Gerwasia*.

Dietel, P. (1928) .. .. Die natürlichen Pflazenfamilien **6** : 78

Mains, E. B. (1938) .. .. *Amer. J. Bot.* **25** : 677-679

Sydow, P. & H. (1915) .. Monogr. Ured. III p. 163

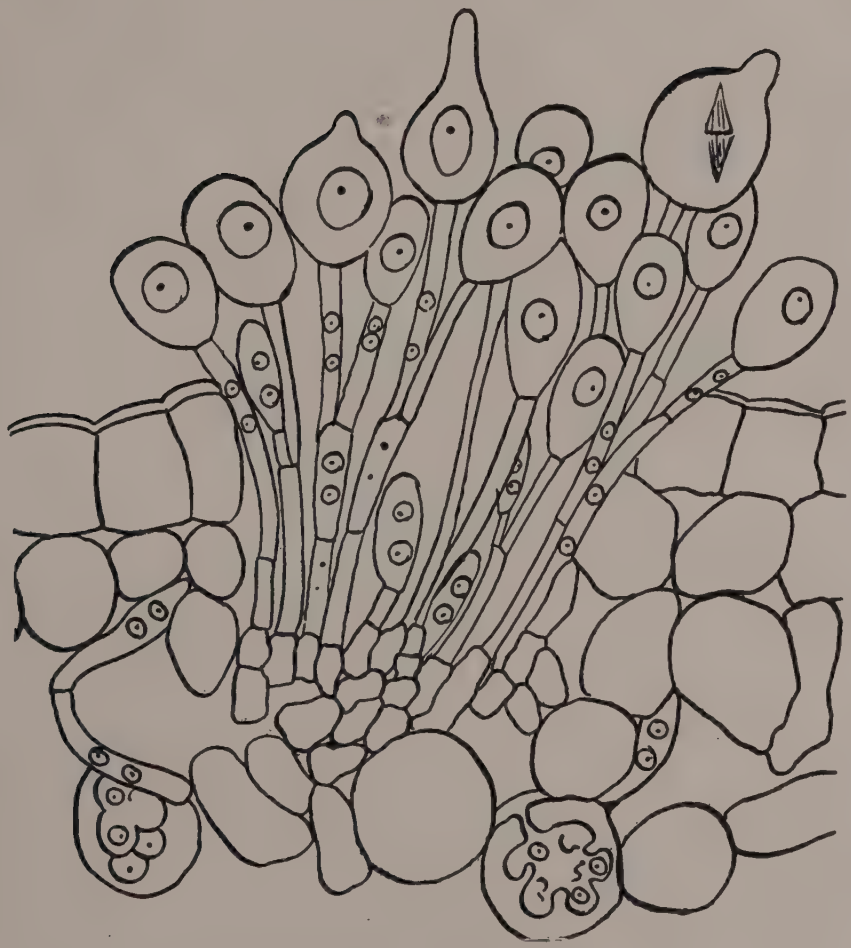


Fig. 12. Botryorhiza

14. **BOTRYORHIZA** Whetzel and Olive in *Amer. J. Bot.* 4, p. 47, 1917. Fig. 12.

Pycnia, aecia and uredia unknown. Telia subepidermal, erumpent, uredia-like; teliospores thin-walled, oval, 1-celled, borne simply on long pedicels, each germinating at once to produce a promycelium with 4 sporidia. Haustoria botryose or irregularly branched.

TYPE SPECIES : *Botryorhiza hippocrateae* Whetzel and Olive on *Hippocratea volubilis*

DISTRIBUTION : Puerto Rico (Single species)

NOTES : Generic name is derived from the fact that this form produces large botryose haustoria. Very little is known about the genus on the whole except that it has uredioid telia.

Arthur, J. C. (1925) .. .. .. N. Amer. Fl. **8** : 703
Dietel, P. (1928) .. .. Die natürlichen Pflanzenfamilien **6** : 80
Olive, E. W. (1918) .. .. *Mem. Brooklyn Bot. Gdn.* **1** : 337-341

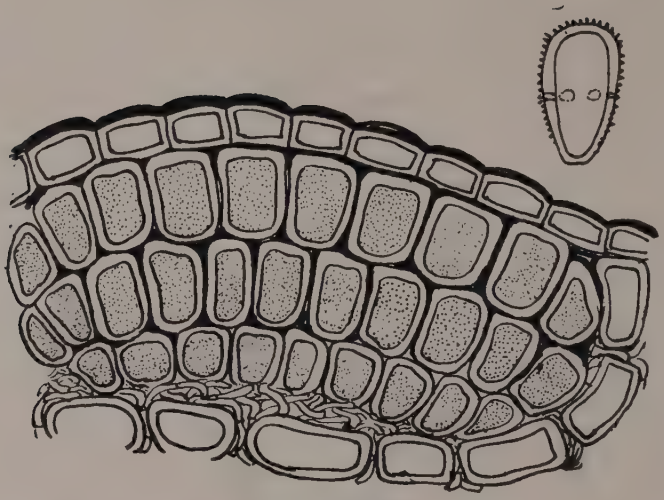


Fig. 13. Bubakia

15. **BUBAKIA** Arthur in *Result. Sci. Congr. Bot. Vienne*, p. 338, 1906. Fig. 13.

Pycnia subcuticular. Aecia uredinoid. Uredia subepidermal erumpent, pulverulent, without peridium or paraphyses; urediospores pedicellate or apparently sessile with pale yellow wall and indistinct equatorial germ pores. Telia non-erumpent, compacted into lenticular crusts, developing in irregular succession from the basal hymenium resulting in younger spores alternating and wedging between older ones and never occurring in chains; 1-celled; wall coloured.

TYPE SPECIES: *Bubakia crotonis* (Cke.) Arthur on *Croton capitatus* (Euphorbiaceae)
DISTRIBUTION: Widely in North and South America

NOTES: The genus is closely related to *Phakopsora* and *Angiopsora*. It was incorrectly made a synonym of *Schroeteriaster* by Sydows (1915) and Arthur himself reduced it to synonymy of *Phakopsora* (1925). Later 1934) he recognised it as a valid genus.

Subcuticular pycnia were suspected by Jackson (1931) and later Cummins (1940) found them in *Bubakia ehretiae* (Hirats.) Ito. As already pointed out under *Angiopsora*, the telia of *Bubakia* and *Phakopsora* are structually alike in being lenticular, non-erumpent and with non-catenulate teliospores. The characters of uredia alone separate the two genera. Absence of hyphoid peridium or paraphyses bordering the uredia and the occurrence of equatorial germ pores in *Bubakia* are the distinguishing characters.

Cummins (1936) states that there are no species known to have uredinoid aecia in the Melampsoraceæ and none have equatorial germ pores except *Bubakia* and some species of *Hyalopsora*. The life cycle of *Phakopsora* is as yet imperfectly known so that the question of the status of *Bubakia* as a genus distinctly separate from *Phakopsora* cannot be finally decided.

Arthur, J. C. (1907) (1925) .. N. Amer. Flora **7** : 104 & 674
Arthur, J. C. ..(1934.. .. Manual of Rusts, p. 59
Cummins, G. B. (1936) .. *Mycologia* **28** : 111, 127
Cummins, G. B. (1940) .. *Mycologia* **32** : 370
Dietel, P. (1928) .. .. Die natürlichen Pflanzenfamilien **6** : 48
Jackson, H. S. (1931) .. *Mycologia* **23** : 466
Sydow, H. and P. (1915) .. Monogr. Ured. III.

16. **CAEOMA** Link in *Magz. Ges. Naturf. Freunde Berlin* III, p. 5, 1809.

Pycnia, uredia and telia unknown. Aecia without peridium; aeciospores catenulate, 1-celled, globoid, verrucose to catenulate, thick-walled above.

TYPE SPECIES: *Cœoma saxifragarum* (DC.) Link on *Saxifraga aizoides*

DISTRIBUTION: Widely distributed.

NOTES: Under this form-genus are placed aecia without peridium. Absence of peridia makes them inconspicuous on the host. Many of them are doubtless heterœcious and belong to the Melampsoraceæ. The uredial stages of genera like *Coleosporium* are cæomoid and the urediospores are catenulate.

An omnibus genus including *Aecidium*, *Roestelia*, *Uredo*, *Ustilago* and *Cœomurus* as subgenera. The type is based on a concept but *Cœoma saxifragarum* was chosen by Clements and Shear as lectotype.

17. **CALIDION** Sydow H. & P. in *Ann. Mycol.* **16,** p 242, 1919.

Uredo ?

Only uredia known. Uredia small, cinnamon brown, without peridium and surrounded by paraphyses; paraphyses compact, free above, coloured, tubular and very thick-walled, strongly curved inwards and enclosing like a nest relatively few and sparsely formed urediospores; urediospores several, (2—6) arising on a common hyaline basal cell; or urediospores pedicellate, produced singly, aculeate, spiny, yellow to yellowish brown, germ pores obscure.

TYPE SPECIES: *Calidion lindsaeae* (P.Henn.) Sydow on *Lindsœa* sp. (Polypodiaceae)

DISTRIBUTION: Brazil, South America. (Single species).

NOTES: The genus was set up by Sydows to accomodate the uredial stage of a fern rust on *Lindsaea* which differed in the characters of the sorus from those of other fern rusts so far known. The type of uredium is reminiscent of *Crosspsora zizyphi* (Mundkur and Thirumalachar, *Mycol. Papers*, C. M. I., No. **16**), *Prospodium* (Cummins, *Ann. Mycol.* **35**: 5-21, 1937), and *Olivea* (Arthur, *Mycologia* **9**: 60, 1917). In fact Dietel(1928) includes *Calidion* under the tribe "Oliveæ". In the absence of the telial stage, *Calidion* has to be maintained only on the basis of the host group, (Pteridophytes in this case), but recent studies do not lend support to such a practice. Members of the Pucciniaceæ, viz., *Puccinia lygodii* occur on the fern, *Lygodium;* species of *Desmella* which were considered to be restricted to ferns are known to occur on *Berberis*. The sporogenous basal cells in the uredia or telia do not have diagnostic value in separating genera. The practice of establishing genera of rusts on the basis of host groups does not appear to be desirable.

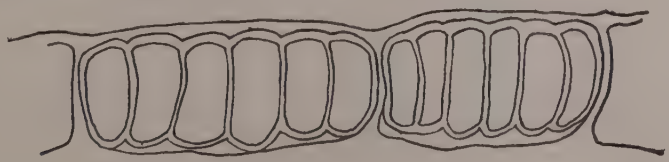


Fig. 14. Calyptospora

18. **CALYPTOSPORA** Kuehn in *Hedwigia*, 8, p. 81, 1869. Fig. 14.

Pycnia epiphyllous, minute, subcuticular. Aecia hypophyllous, subepidermal, minute, peridiate; peridia colourless, firm, irregularly polygonal; aeciospores globose, subglobose to broadly elliptical, orange red. Uredia wanting. Telia caulicolous, forming a continuous layer around the abnormally elongated and thickened stems; teliospores intracellular, formed in the epidermal cells, subglobose, ellipsoidal,

oblong or prismatic, 3 to 5-celled (mostly four) with vertical septa, smooth, golden-brown. Promycelium external, typically four-celled.

TYPE SPECIES : *Calyptospora goeppertiana* Kuehn on *Vaccinium vitis-idaei* (Vacciniaceae)

DISTRIBUTION : Central Europe (one species)

NOTES : A heterœcious rust with O. & I. on Pinaceæ and III on Vacciniaceæ. Uredia unknown. Teliospores are intra-epidermal without any indication externally of their presence.

Sydows (1915) and Dietel (1928) state that pycnia are wanting but Arthur (1907), Hiratsuka (1936), and Weir and Hubert (1918) record their presence. Arthur (1934) has reduced the genus to the synonymy of *Pucciniastrum*.

Calyptospora is a life-cycle variant of *Thekopsora* from which it differs in lacking uredia. The genus has been retained by most of the European Urediniologists and Sydow states that that has been done because of usage and custom. It is not certain whether this practice of conserving names of genera occuring on plants of relatively little economic importance should be followed.

Arthur, J. C. (1907) .. N. Amer. Flora **7** : 113
Dietel, P. (1928) .. .. Die naturlichen Pflanzenfamilien, **6** : 39
Faull, J. H. (1939) .. .. *J. Arnold Arb.* **20** : 104-113
Hartig, R. (1882) .. .. Lehrb. Pflanzenkr, p. 56-61
Hiratsuka, N. (1936) .. Monograph of the Pucciniastraceæ, 374
Sydow, P. & H. (1915) .. Monogr. Ured. III, p. 470
Weir, J. R. and Hubert, E. E. (1918) *Phytopathology* **8** : 114-118

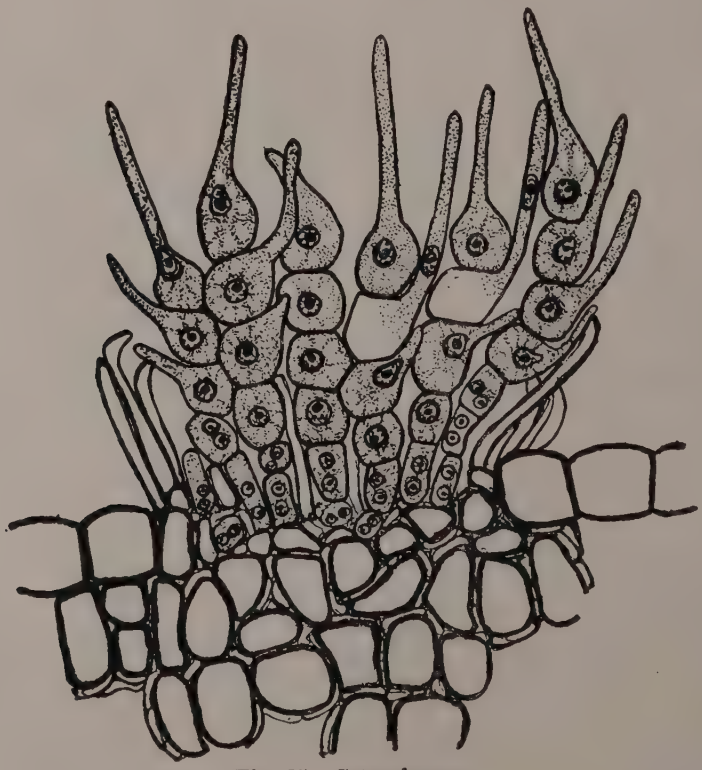


Fig. 15. Catenulopsora

19. **CATENULOPSORA** Mundkur *Ann. Bot.* (n. s.), **7**, p. 216, 1943. Fig. 15.

Pycnia, if present, sparse, subepidermal. Aecia unknown. Uredia subepidermal, erumpent, paraphysate ; paraphyses cylindrical, intermixed with urediospores and forming a marginal ring, slightly incurved. Urediospores borne singly on short pedicels with a single germ pore. Telia at first subepidermal, erumpent, paraphysate, forming long chains ; chains not laterally united, up to 24 spores in a chain and each teliospore firmly united to the one below, not separable even at maturity, basal spores pedicellate ; teliospores without germ pores, germinating at once by continuation in growth of the apical region into a long, elongate promycelium parallel to spore-chain ; promycelium 4-celled at upper end, with globose sporidia on sterigmata.

TYPE SPECIES : *Catenulopsora flacourtiae* Mundkur and Thirumalachar on *Flacourtia sepiaria* Roxb. (Flacourtiaceae)

DISTRIBUTION : India and Ceylon. (4 species).

NOTES : The genus comes close to *Kuehneola* Magnus in possessing teliospores in semi-permanent chains of one-celled spores, the chains not laterally coalescent but falling apart. In *Kuehneola* there is a distinct germ pore in the teliospores through which the promycelium is exerted out. As against this in *Catenulopsora* the apical portion of the teliospore even before germination becomes umbonate or protrudes into a beak-like structure. There is no germ pore and the teliospores germinate by the prolongation of this beak-like structure into a promycelium.

Mundkur, B. B. and Thirumalachar, M. J. (1946). Revisions of and additions to Indian fungi I. *Mycol. Pap., Imp. Mycol. Inst.* **16**, P. 16

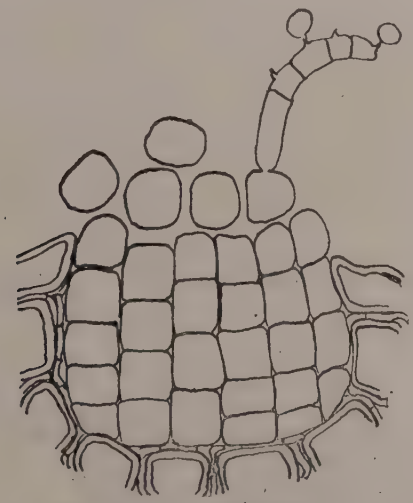


Fig. 16. Cerotelium.

20. **CEROTELIUM** Arthur in *Bull. Torrey Bot. Cl.* **33**, p. 30, 1906. Fig. 16.

Pycnia subcuticular, applanate to conoid. Aecia subepidermal, cupulate and peridiate ; aeciospores orange-yellow. Uredia subepidermal, surrounded by incurved paraphyses developing from hyphoid peridium or none ; urediospores usually hyaline and sessile with scattered germ pores. Telia subepidermal, erumpent, waxy, becoming pulverulent at apex at maturity ; teliospores 1-celled, hyaline, developing in chains ; telial chains laterally coalescent at the base to form

short columnar structures ; columns firm at base becoming pulverulent at apex, with mature teliospores germinating immediately. Promycelium external, 4-celled.

TYPE SPECIES : *Cerotelium canavaliae* Arthur on *Canavalia ensiformis* (Leguminosae)

DISTRIBUTION : Wide (20 species)

NOTES : The genus is closely related to *Kuehneola* Magnus from which it can be separated by differences in the structure of the uredium and telium. Urediospores in *Kuehneola* are distinctly pedicellate and do not show paraphyses typical of *Cerotelium*. Teliospores in *Kuehneola* are in distinct chains but the chains do not show any lateral coalescence, being free up to the base and falling apart.

Sydows (1915) did not recognise the genus at first and made it a synonym of *Kuehneola* and later they proposed it as synonym of *Dietelia*. *Dietelia* however is distinctly a separate genus characterised by a peridiate telium. In his later work, H. Sydow recognised the genus and described several species of it.

Arthur, J. C. (1907) .. .. North Amer. Fl. **7** : 123
Arthur, J. C. (1917) .. .. *Bull. Torrey Bot. Cl.* **44** : 501-511
Arthur, J. C. (1934) .. .. Manual of Rusts. p. 61
Dietel, P. (1923) .. .. *Ann. Mycol.* **21** : 84-86
Dietel, P. (1928) .. .. Die natürlichen Pflanzenfamilien **6** : 56
Mains, E. B. (1921) .. .. *Amer. J. Bot.* **7** : 442-451
Sydow, P. & H. (1915) .. Monogr. Ured. III pp. 524-525

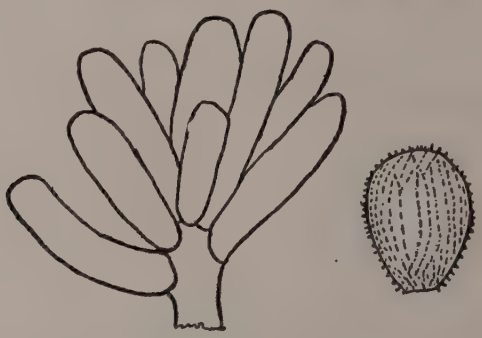


Fig. 17. Chaconia

21. **CHACONIA** Juel in *Bihang K. Svenska Vet. Akad. Handl.* **23**, Afd. 3, No. 10 p. 12, 1897. Fig. 17.

Syn. *Ypsilopsora* Cummins in *Bull. Torrey Bot. Cl.* **68** : 43-48, 1941
Bitzea Mains in *Mycologia* **31**, p. 38, 1939

Pycnia subcuticular. Uredia subepidermal, pulverulent ; urediospores obovoid to ellipsoid, echinulate or finely verruculose in irregular lines. Telia subepidermal, soon naked, teliospores clavate to cylindric hyaline, thin-walled, sessile, germinating immediately at maturtiy ; promycelium external, 4-celled.

TYPE SPECIES : *Chaconia alutacea* Juel on *Calliandra sp.* (error for *Pithecolobium divaricatum*) (Leguminosae)

DISTRIBUTION : Paraguay, India, N. Africa (4 species)

NOTES : Occurrence of sporogenous basal cells in the teliospores was stressed upon by earlier investigators as one of the important diagnostic characters of the genus. Thirumalachar and Cummins (1949) have pointed out that this is a variable character and has no generic significance. It only represents one of the modes of teliospore development and occurs independently in species of several genera.

Subcuticular pycnia and subepidermal telia with sessile 1-celled hyaline teliospores, germinating immediately at maturity, characterises *Chaconia*. The same

characters are duplicated in *Ypsilopsora* and *Bitzea* which are synonyms of *Chaconia*.

Juel described only telia, and uredia were discovered by Mains. *Chaconia* has been placed under Melampsoraceæ by Sydows for they considered the basal cells were united. Though the teliospores are sessile, they are not laterally coalescent to form a waxy crust. Arthur placed the genus in Skierkiaceæ, along with *Skierka*, *Ctenoderma* and *Sphenospora* which is not also correct. The genus has been correctly placed in the Oliveæ by Dietel along with *Olivea*, *Chrysocelis* and *Goplana*.

Arthur, J. C. (1926) .. .. North. Amer. Fl. **7** : 734
Dietel, P. (1928) .. .. Die natürlichen Pflanzenfamilien, **6** : 54
Mains, E. B. (1938) .. .. *Bull. Torrey Bot. Cl.* **65** : 625-629
Sydow, P. & H. (1915) .. Monogr. Ured. III, p. 421
Thirumalachar, M. J. and Cummins, G. B. (1948). *Mycologia* **40** : 417-422
Thirumalachar, M. J. and Cummins, G. B. (1949). *Mycologia* **41** : (in press)

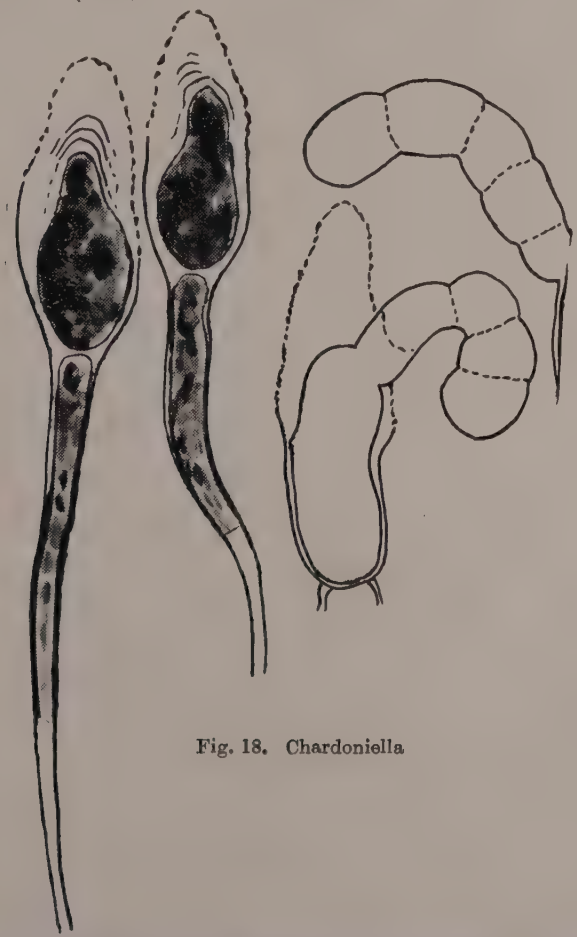


Fig. 18. Chardoniella

22. **CHARDONIELLA** Kern in *Mycologia* **31** , p. 375, 1939. Fig. 18.

Pycnia subepidermal, provided with ostiolar paraphyses. Telia subepidermal, erumpent in more or less cylindric to filiform columns forming dry horn-like masses ; teliospores 1-celled, pedicellate ; promycelium external, typically 4-celled.

TYPE SPECIES : *Chardoniella gynoxidis* Kern on *Gynoxis* sp. (Compositae)

DISTRIBUTION : Columbia. (one species)

NOTES : Teliospores are produced in *Cronartium*-like spore-tendrils. Superficially they appear like *Trichopsora* Lagerheim which occurs on the same host but the teliospores of *Trichopsora* germinate by an internal promyceliun There is a good deal of resemblance with *Kernella* Thirumalachar but in that genus the teliospores are two-celled and pedicellate. In both *Chardoniella* and *Kernella* the teliospores are not formed in catenations but the younger spores are formed between older ones and laterally adhere to form spore-tendrils.

Thirumalachar, M. J. (1946). *Mycologia* **38** : 679-686

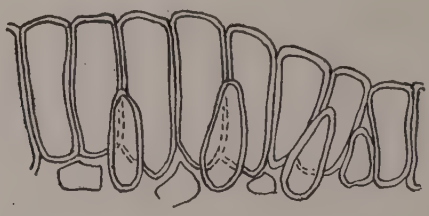


Fig. 19. Chnoopsora

23. **CHNOOPSORA** Dietel in *Ann. Mycol.* **4,** p. 423, 1906. Fig. 19.

Pycnia subepidermal, inconspicuous. Aecia round or irregular, pale orange, without peridium or paraphyses and typically *Cæoma*-like. Uredia unknown. Telia subepidermal, erumpent, naked, forming firm crusts ; teliospores uniseriate, compact and laterally coalescent, 1-celled, oblong, prismatic, subhyaline ; young spores developing between older ones ; provided with indistinct germ pores. Germinating immediately at maturity by 4-celled external promycelium.

TYPE SPECIES : *Chnoopsora sancti-johannis* (Barclay) Dietel on *Hypericum cernuum* (Hypericincae)

DISTRIBUTION : India, Japan, Africa (4 species)

NOTES : The genus is closely related to *Melampsora* from which it differs in possessing hyaline, non-resting type of teliospores. In that respect the telia and teliospores closely resemble those of *Aplopsora* Mains from which it differs, however, in possessing successive development of teliospores from the basal hymenium.

Dietel, P. (1928) .. .. Die natürlichen Pflanzenfamilien **6** : 47
Sydow, P. & H. (1915) .. Monogr. Ured. III, p. 396

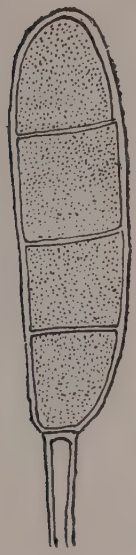


Fig. 20. Chrysella

24. **CHRYSELLA** Sydow in *Ann, Mycol.* **24,** p. 292, 1926. Fig. 20.

Pycnia subepidermal. Aecia and uredia unknown. Telia subepidermal, erumpent, cushion-like, waxy, golden yellow; teliospores on long, hollow, laterally joined pedicels, unicellular, germinating immediately by internal promycelium formation.

TYPE SPECIES : *Chrysella mikania* Sydow on *Mikania hirsutissima* (Compositeae)

DISTRIBUTION : Central America (one species)

NOTES : Telia are bright, large, lustrous golden yellow and contain abundant moisture. Following spore germination the teliospore shrink and collapse, so that the details of the sorus and spore structure are hard to make out. Because of paucity of good material it is not yet clear if the description of this monotypic genus is correct in all respects. As already stated before, *Chrysella* is separated from *Achrotelium* by its subepidermal pycnia in contrast to subcuticular condition in the latter.

Clements, F. E. and Shear, C. L. Genera of Fungi. pp. 150 & 334 (1931).
Dietel, P. (1928) .. .. Die natürlichen Pflanzenfamilien **6** : 78

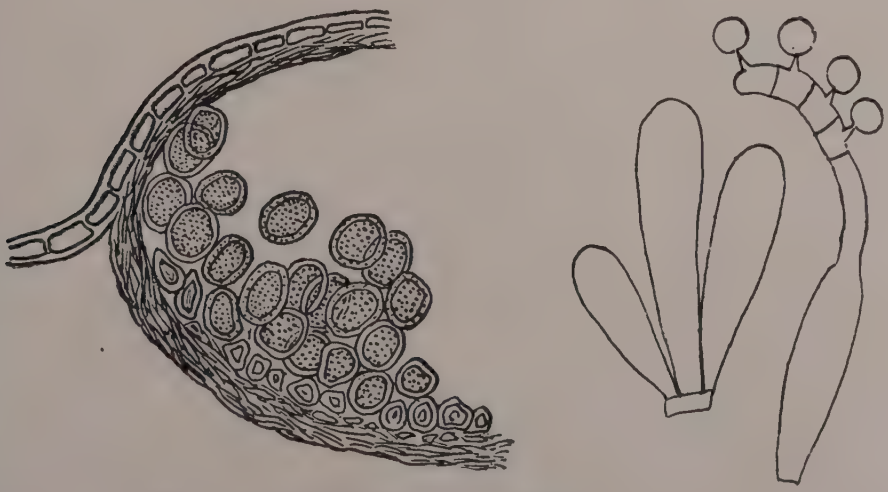


Fig. 21. Chrysocelis (Aecium & Telium)

25. **CHRYSOCELIS** Lagerheim & Dietel in *Mem. Soc. Neuch. Sci. Nat.* **5, P.** 542 1913. Fig. 21.

Pycnia subepidermal, deep seated, globose or egg-shaped. Aecia subepidermal, covered by the host epidermis, opening by a central round pore, without peridium ; aeciospores globoid or ellipsoid, hyaline, verruculose. Uredia unknown. Telia subepidermal, soon naked, waxy, flat, golden yellow; teliospores club-shaped or cylindrical, sessile, terete, 1-celled, with thin hyaline, smooth membrane ; germinating immediately at maturity by 4-celled external promycelium.

TYPE SPECIES : *Chrysocelis lupini* Lagerheim and Dietel on *Lupinus* sp. (Leguminosæ)

DISTRIBUTION : South America, Philippines, India (Four species)

NOTES : The cylindric, hyaline, sessile teliospores germinating immediately at maturity resemble those of *Chaconia* from which this genus differs in possessing subepidermal pycnia. In *Chrysocelis muehlenbeckiæ* the telium is like an acervulus according to Dietel (1914) with fragile promycelial cells which round off into sporidia-like structures. Arthur (1918) disagrees with the view that this genus should be in the Pucciniaceæ and recommends its inclusion in the Melampsoraceæ but Dietel's grouping of it in the tribe "Oliveæ" along with *Chaconia* and others seems to be quite logical.

Arthut, J. C. (1918) .. .. *Bot. Gaz.* **65** : 463
Arthur, J. C. (1925) .. .. North Amer. Fl. **7** : 702
Dietel, P. (1914) .. .. *Ann. Mycol.* **12** : 83-88
Dietel, P. (1928) .. .. Die natürlichen Pflanzenfamilien **6** : 55
Mains, E. B. (1939) .. .. *Mycologia* **31** : 37

26. **CHRYSOCYCLUS** : Sydow in *Ann. Mycol* **23,** p. 322, 1925. Fig. 22.

Syn. *Holwayella* Jackson in *Mycologia*, **18** p. 49, 1926

Pycnia subepidermal, globose. Aecia and Uredia unknown. Telia subepidermal, erumpent, forming concentric circles, naked, bright orange ; teliospores provided with long pedicels, 2-celled, hyaline, thin-walled ; germinating by the upper cell growing, soon after its formation prolonging into a tubular 4-celled promycelium at the apex of the lower cell putting forth laterally a germ tube at its, upper end which like-wise becoming a 4-celled) promycelium. Sporidia large and globose.

TYPE SPECIES : *Chrysocyclus cestri* (Diet. & Henn. Sydow on *Cestrum strigillatum* (Solanaceae)

DISTRIBUTION : Bolivia (2 species)

NOTES : Jackson (1926) in tracing the development and germination of the teliospores describes the 2-celled stage with no sharp differentiation between the spore and the promycelium. There is no germ pore but germination takes place by the prolongation

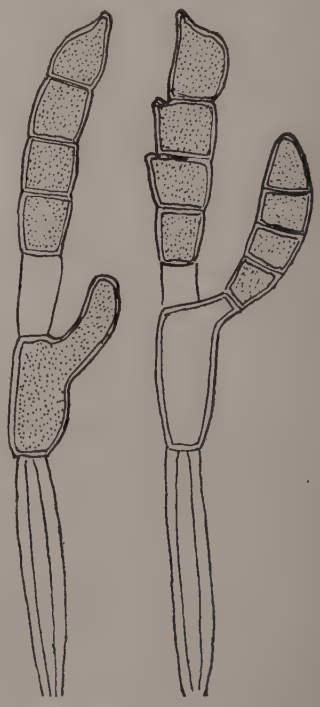


Fig. 22. Chrysocyclus

of the spore-apex. The upper cells gradually elongate and the lower cell simultaneously develops at one side in like manner giving the structure a 'mitten-like' shape, in which the thumb is as large as hand portion, both being cylindric. He further states (1931) that the genus presents a lepto-Puccinia in which the sori are waxy and the basidium develops from the spore without interruption. It represents a simplification in morphology that has arisen in tropical rusts whose teliospores germinate at once.

Davidson (1932) thinks that the 'mitten-like' form of the spores and waxy appearance of sori which are arranged in concentric layers around the pycnia together with the method of germination are characters sufficiently distinctive to justify present separation.

Dietel, P. (1928) .. .. Die natürlichen Pflanzenfamilien. **6** : 79
Davidson, R. W. (1932) .. *Mycologia* 24 : 223
Jackson, H. S. (1926) .. *Mycologia* **18** : 49
Jackson, H. S. (1931) .. *Mycologia* **23** : 104.

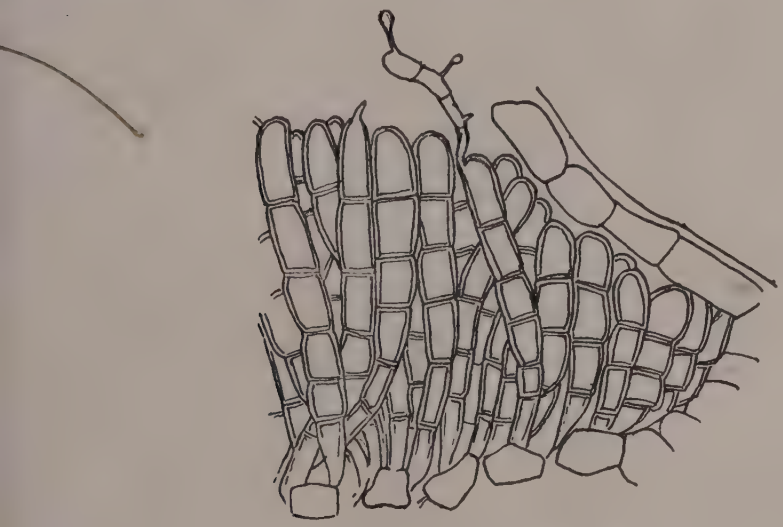


Fig. 23. Chrysomyxa

27. **CHRYSOMYXA** Unger in *Beitr. Vergl. Path.* p. 24. 1840, Fig. 23.

Syn. *Barclayella* Dietel in *Hedwigia*, 29 : 266, 1890

Melampsoropsis (Schroeter) Arthur in *Result. Sci. Congr. Bot. Vienne*, p. 338, 1906

Pycnia subepidermal, deeply immersed, amphigenous with ostiolar paraphyses. Aecia subepidermal, erumpent, with laterally compressed peridium whose membrane dehisces irregularly at the apex ; aeciospores in chains, verruculose. Uredia subepidermal, erumpent, pulverulent, surrounded by rudimentary or evanascent peridium ; urediospores catenulate, globose, oblong or lanceolate, with hyaline epispore and without germ pores. Telia subepidermal, erumpent, waxy at first, later fluffy ; teliospores catenulate, chains laterally coalscent, one-celled, smooth, polygonal to cubical

with hyaline epispore, germinating immediately at maturity ; promycelium external, 4-celled with globose sporidia.

TYPE SPECIES : *Chrysomyxa abietis* (Wallr.) Unger on *Pinus abies* (Pinaceae)

DISTRIBUTION : Wide spread

NOTES : The genus includes heteroecious rusts with pycnia and æcia on *Picea* and uredia and telia on various dicotyledonous herbs and shrubs such as *Empetrum*, *Pyrola*, *Rhododendron*, *Ledum*, etc. The occurrence of urediospores and teliospores in chains is characteristic of the genus. Uredia are peridiate and urediospores in chains are usually separated by sterile intercalary disjunctor cells. Teliospores are compacted into pulvinate sori and germinate without a rest period. The promycelium and sporidia impart a velvety appearance to the sori.

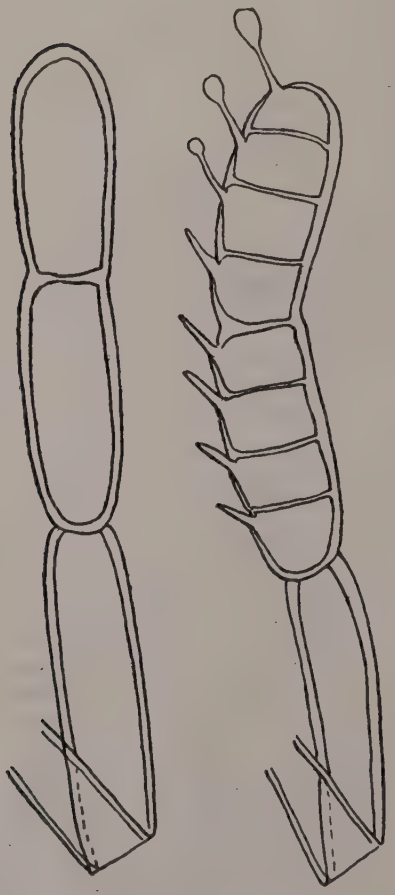


Fig. 24. *Chrysopsora*

The genus *Barclayella* was founded by Dietel because of lack of sporidial development. Instead, the cells of the promycelium rounded off into sporidia. It was, however, found that that was an abnormal type of development due to unsuitable conditions (the material had been preserved in salt water). *Barclayella* is undoubtedly a synonym of *Chrysomyxa*.

Arthur, J. C. (1925) .. North Amer. Fl. **7** : 690

Dietel, P. (1928) .. Die natürlichen Pflanzenfamilien **6** : 44

Sydow, P. & H. (1915) Monogr. Ured. III, 502-504

28. **CHRYSOPSORA** Lagerheim in *Ber. dtsch. bot. Ges.* **9**, p. 345, 1892. Fig. 24.

Pycnia subepidermal, deeply sunk. Aecia and uredia unknown. Telia subepidermal, waxy at first, erumpent, elevated in concentric circles, bright orange ; teliospores slightly gelatinous, with long pedicels formed out of 2 superimposed cells with hyaline membrane whose contents soon transformed by delicate cross-walls into an internal promycelium. Sporidia large, egg-shaped.

TYPE SPECIES : *Chrysopsora gynoxidis* Lagerheim on *Gynoxis pulchella* (Compositae)

DISTRIBUTION : South America (one species)

NOTES : The genus was placed under Coleosporiaceæ by Sydows on account of the occurrence of internal promycelium. They further remark that it is the only genus in the family with pedicellate teliospores. But it is now becoming apparent that internal promycelium type of germination has occurred independently in different families and is not a taxonomic character of any one family.

Arthur, J. C. (1924) .. .. North Amer. Fl. 7 : 662

Dietel, P. (1928) .. .. Die natürlichen Pflanzenfamilien 6 : 79

Sydow, P. & H. (1915) .. Monogr. Uredin. III, 667

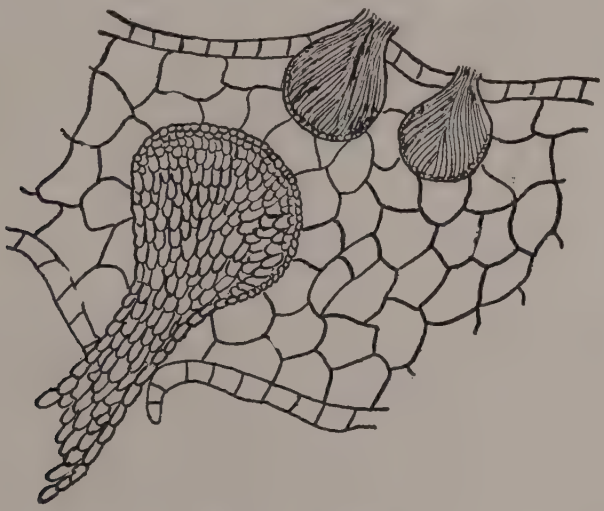


Fig. 25. *Cionothrix*

29. **CIONOTHRIX** Arthur in *North Amer. Fl.* **7**, p. 124, 1907. Fig. 25.

Pycnia subepidermal, deep seated, flat to flask shaped with ostiolar paraphyses. Aecia and uredia unknown. Telia as in *Cronartium*, erumpent, catenulate, spores adhering to form a filiform column, horny when dry ; teliospores ovoid, 1-celled, arranged in series, closely combined into columnar masses often remaining together in large numbers. Promycelium external and typically four-celled.

TYPE SPECIES : *Cionothrix prælonga* (Wint.) Arthur on undetermined Compositae.

DISTRIBUTION : South America, Australia. (8 species)

NOTES : Sydows (1915) at first considered the genus as synonym of *Cronartium* but later recognised it as a valid genus. Arthur maintains the genus for short cycled

Cronartium and places it in the Melampsoraceæ but Dietel has grouped it in the Pucciniaceæ under *Pucciniosireae*.

Dietel, P. (1928) .. .. Die natürlichen Pflanzenfamilien **6 : 94**
Sydow, P. & H. (1915) .. Monogr. Ured. III, 559

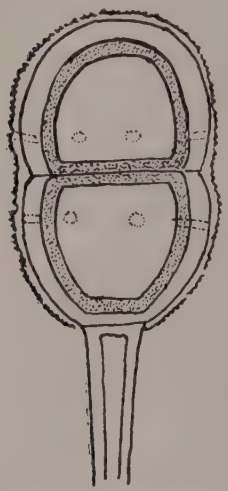


Fig. 26. *Cleptomyces*

30. **CLEPTOMYCES** Arthur in *Bot. Gaz.* **65,** p. 464, 1918. Fig. 26.

Pycnia subepidermal, flask-shaped, with ostiolar paraphyses. Aecia and uredia unknown. Telia subepidermal, erumpent ; teliospores pedicellate, 2-celled, *Puccinia*-like, with three-layered walls inner layer firm and coloured, outer more or less hygroscopic, colourless, overlaid by verrucose cuticle ; germ-pores 4 or more, scattered or equatorial, in each cell of the spore.

TYPE SPECIES : *Cleptomyces lagerheimianus* (Dietel) Arthur on *Aegiphila* sp. Verbenaceae.

DISTRIBUTION : Ecuador, South America (2 species)

NOTES : The type species of the genus was first identified by Dietel as *Puccinia* and later transferred to *Uropyxis*. The genus differs from *Uropyxis* in possessing subepidermal pycnia as against subcuticular ones in *Uropyxis*. In this respect it comes close to *Cumminsiella* which has subepidermal pycnia and *Uropyxis*-like telios pores. The only differences is in the number of germ pores : in *Cumminsiella* there are two lateral germ pores whereas in *Cleptomyces* there are four or more which are lateral or equatorial.

Dietel, P. (1928) .. .. Die natürlichen Pflanzenfamilien **6 : 65**

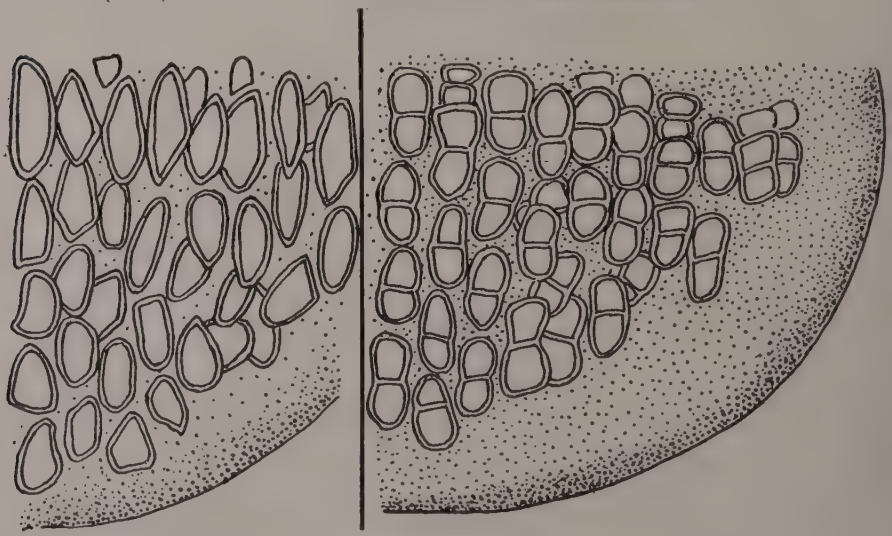


Fig. 27. *Coleopuccinia.*

31. **COLEOPUCCINIA** Patouillard in *Rev. Mycol.* **11,** p. 35, 1889. Fig. 27, Syn. *Coleopucciniella* Hara in Parasitic Fungi of Japan, p. 262, 1936 (in Japanese).

Fig. 27 Coleopuccinia

Pycnia, æcia and uredia unknown. Telia subepidermal, deeply immersed, waxy, orange or yellowish-red, gelatinous ; teliospores compacted into a gelatinous mass 1- (or 2 ?) celled, hyaline, long pedicelled at first in the young sorus which gelatinizes at maturity ; spore-masses getting incrusted in the waxy gelatinous mass ; teliospores germinating *in situ* producing a four-celled external promycelium with globose sporidia.

TYPE SPECIES : *Coleopuccinia sinensis* Pat. on *Amelanchier* sp. (*Cotoneaster* sp.) (Rosaceae)

DISTRIBUTION : China, Japan (4 species)

NOTES : The genus was established for a rust collected in China. The teliospores were described as oblong, 1-sepate and pedicellate but no mention was made of its catenulate nature. In the description of *Coleopuccinia simplex* Dietel (1909) described the teliospores as 1-celled. Sydows describing *Coleopuccinia sinensis* and *Coleopuccinia simplex* stated that they are catenulate, 2-celled and embedded in a waxy gelatinous matrix, without germ-pores and with germination unknown. No mention of the pedicel was made. A recent study of *Coleopuccinia simplex* and *Coleopuccinia kunmingensis* Tai by Tai (1948) has shown that the spores are 1-celled and pedicellate. Hara (1936) basing the 1-celled character of *Coleopuccinia simplex*, established the genus *Coleopucciniella* to separate it from the 2-celled *Coleopuccinia*. The genus has been recognised by Hiratsuka but Tai considers it as synonymous with *Coleopuccinia*. Dietel places the genus near *Gymnosporangium* with which it has many characters in common and a careful study of the type, *Coleopuccinia sinensis* may reveal interesting data. Teliospores germinate by an external 4-celled promycelium. In some cases the germ tubes produce a secondary appressorium-like body (Tai 1948) similar to that produced during urediospore germination of some rust species.

Dietel, P. (1909) .. .. *Ann. Mycol.* **7** : 355
Dietel, P. (1923) .. .. *Ann. Mycol.* **21** : 87
Dietel, P. (1928) .. .. Die natürlichen Pflanzenfamilien, **6** : 77
Hara, K. (1936) .. .. Parasitic fungi of Japan, p. 262.
Sydow, P. & H. (1915) .. Monogr. Ured. III. p. 514-515
Tai, F. L. (1948) .. .. *Acta Agriculturæ* (*China*) **1** : 97-103, 1948

Fig. 28. *Coleosporium*

32. **COLEOSPORIUM** Lèveillè in *Ann. Sci. Nat. Bot.* 3, Ser, VIII, p. 343. 1847 Fig. 28.

Syn. *Erannium* Bon. Zur Kenntniss.....Coniomyceten und Cryptomyceten, p. 15 1860
Stichopsora Dietel in Engler's *Bot. Jb.* **27** : 565, 1899
Synomyces Arthur in North Amer. Fl. **7** : 661, 1924

Pycnia subepidermal, flattened to conoid, opening by a slit, with ostiolar paraphyses. Aecia peridermium-like, subepidermal, laterally compressed, surrounded by a peridium composed of a single layer of cells, dehiscing irregularly ; æciospores catenulate, verruculose and with distinct germ pores. Uredia subepidermal, erumpent, without peridium, golden yellow ; urediospores globose to oblong, produced in chains, manifesting sterile, intercalary cells. Telia subepidermal, flat to convex, somewhat waxy, becoming gelatinous on germination ; teliospores 1-celled, cylindric, sessile, laterally coalescent, thin-walled germinating at maturity by an internal promycelium ; sporidia borne on long sterigmata.

TYPE SPECIES : *Coleosporium rhinanthacearum* (DC.) Lèv. on *Rhinanthus glaber* (type selected by Arthur, *lectotype ?*)

DISTRIBUTION : Wide spread (85 species).

NOTES : The genus has a wide geographic distribution in warmer and temparate regions. Pycnia and æcia are produced on *Pinus* while uredia and telia are borne on dicotyledonous plants.

The development of internal promycelium in the form of a phragmobasidium is characteristic of most of the species. In *Coleosporium pulsatillæ*, Weir (1912) showed that vertical septations took place as in Tremellaceæ. Sterigmata are of unequal length, bearing sporidia above the surface of the sorus.

The genus *Gallowaya* established for microcyclic species of *Coleosporium* on *Pinus virginiana* by Arthur in 1907 was later (1934) merged by him as a synonym of *Coleosporium*. Dodge (1925) showed, however, that the teliospores are catenate in *Gallowaya ;* the genus has been recognised as valid by Dietel (1928), Sydow and others. It is not merely a cyclic variant of *Coleosporium* but the catenulate nature of the teliospores is a distinct feature as pointed by Dodge. No one has yet described a *Coleosporium* in which the basal cells bud out to form a number of spores. This succession of teliospore formation is a distinctive character warranting the recognition of *Gallowaya* as a valid genus. *Coleosporium crowellii* Cummins, also a pine rust reported by Cummins (1938), produces telial horns composed of chains of 10 to 12 teliospores which germinate by the formation of internal promycelium. This rust properly belongs to *Gallowaya* as it has a sorus morphologically distinct from that of *Coleosporium*.

Arthur, J. C. (1907) .. .. North Amer. Fl. **7** : 85
Arthur, J. C. (1934) .. .. Manual of Rusts
Cummins, G. B. (1938) .. *Phytopathology* **28** : 522-523
Dietel, P. 1928 .. .. Die natürlichen Pflanzenfamilien, **6** : 45
Dodge, B. O. (1925) .. .. *J. Agric. Res.* **31** : 641-651
Magnus, P. (1902) .. .. *Ber. dtsch. bot. Ges.* **20** : 334-339
Sydow, P. & H. (1915) .. Monogr. Ured. III p. 596-598
Weir, J. R. (1912) .. .. *New Phytologist* **11** : 129-139

Fig. 29. *Corbulopsora*

33. **CORBULOPSORA** Cummins in *Mycologia*, **32**, p. 364-365, 1940. Fig. 29.

Pycnia subepidermal, paraphysate ; æcia subepidermal, cupulate, and peridiate ; æciospores catenulate. Uredia and telia similar to each other ; urediospores pedicellate, echinulate, provided with germ pores. Telia subepidermal, erumpent, surrounded by a palisade-like peridium ; teliospores unicellular, arising singly at the apex of pedicels, provided with a single germ pore.

TYPE SPECIES : *Corbulopsora clemensiae* Cummins on *Olearia* sp. (Compositeæ).

DISTRIBUTION : New Guinea and India (3 species).

NOTES : The æciospores and peridial cells in the 2 New Guinean species are large and reminiscent of those found in *Coleosporium* and *Chrysomyxa*. The teliospores on the other hand are pedicellate, 1-celled and resembling those of *Uromyces*. The encircling stockade of peridium composed of long, slender palisade-like cells united laterally is characteristic of the uredia and telia. The teliospores germinate immediately at maturity.

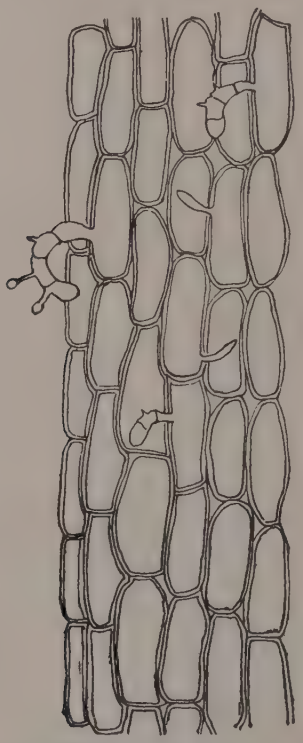


Fig. 30. *Cronartium*

34. **CRONARTIUM** Fries in *Obs. Mycol.* I, p. 220, 1815. Fig. 30.

Pycnia and æcia on the trunks and branches of *Pinus*. Pycnia subepidermal, large, deeply immersed, opening out by longitudinal slits in the bark, without ostiolar paraphyses. Aecia often forming woody galls ; subepidermal, erumpent, at first verruculose, covered by a membranous peridium which splits irregularly and composed of 1 to 4 series of cells which are densely rugose ; æciospores globose to ellipsoid, usually coarsely verrucose. Uredia and telia formed in various dicotyledonous hosts ; uredia subpeidermal, erumpent, minute surrounded by a delicate, often

evanascent peridium, opening out by a central pore ; urediospores borne singly on pedicels, usually echinulate. Telia subepidermal, erumpent, often developing within the uredia ; teliospores 1-celled, catenulate, forming a cylindrical or filiform spore tendril, horny when dry, germinating immediately at maturity by a 4-celled external promycelium with globose sporidia.

TYPE SPECIES : *Cronartium asclepiadeum* Fries (*Cronartium flaccidum* (Alb. & Schw.) (Winter) on *Asclepias* sp. (Asclepiadaceæ)

DISTRIBUTION : Wide spread (20 species)

NOTES : The genus includes rusts with pycnia and æcia on *Pinus* and uredia and telia on dicots and more or less restricted to temperate climates. Short-cycling tendencies are often seen in some species by the formation of repeating secondary æcia without the intervention of the alternate host, a feature confirmed by Klebahn in *Peridermium pini* and by Meinecke in *Cronartium coleosporioides*. The genus closely resembles *Crossopsora* Syd. and *Cionothrix* Arthur which is maintained for microcyclic species resembling *Cronartium*. In *Cronartium* the uredia are peridiate whereas they are superstomal in *Crossopsora*. In one species of *Crossopsora* (C. *sawadae*) pycnia are subcuticular in contrast to subepidermal condition in *Cronartium*.

Arthur, J. C. (1907) .. .. North. Amer. Fl. **7** : 121
Arthur, J. C. (1934) .. .. Manual of Rusts, p. 24-30
Dietel, P. (1922) .. .. *Ann. Mycol.* **20** : 75-76
Dietel, P. (1928) .. .. Die natürlichen Pflanzenfamilien, **6** : 42
Klebahn, H. (1918) .. .. *Flora :* **111-112** : 194
Meinecke, E. P. (1916) .. *Phytopathology* **6** : 225
Sydow, P. & H. (1915) .. Monogr. Ured. III, p. 557-559

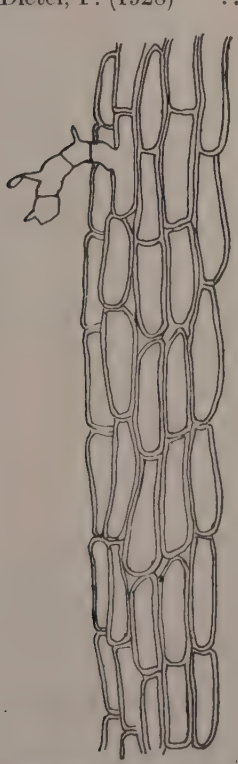


Fig. 31. Crossopsora

35. **CROSSOPSORA** H. & P. Sydow in *Ann. Mycol.* **16**, p. 243, 1919. Fig. 31.

Pycnia subcuticular, crust-like. Aecia deep seated, cupulate, without peridium, opening irregularly. Uredai subepidermal, erumpent, minute, developing the sorus above the epidermis, surrounded by incurved paraphyses which are free at the apex and united at the bas e and pedicels. Telia subepidermal, erumpent, developing showing septations ; urediospores borne singly on *Cronartium*-like spore tendrills, horny when dry ; teliospores 1-celled, oblong or fusiform, slightly coloured, germinating at maturity by an external 4-celled promycelium.

TYPE SPECIES : *Crossopsora zizyphi* (Sydow & Butler) Syd. on *Zizyphus œnoplia* (Rhamnaceæ)

DISTRIBUTION : India, South America, Philippines (12 species)

NOTES : The genus was separated from *Cronartium* by Sydows on account of the presence of incurved paraphyses, coalescent at the base and bordering the uredia. In *Crossopsora zizyphi*, the type of the genus, Mundkur and Thirumalachar showed that the uredial development is superstomal, formed at the apex of columnar hyphal strands. The sori therefore appear superficial, comparable with those of *Prospodium* described by Cummins. This type of uredia is not however found in *Crossopsora premnae* and some others. Arthur and Cummins (1936) have described the pycnial and æcial stages from *Crossopsora sawadae*. The subcuticular pycnia and non-peridiate æcia are quite distinct from those of *Cronartium*. Even the sculpturing of the æciospores in *Crossopsora sawadæ* is stated to be different from that of any other species of *Cronartium*. Pycnia and aecia are known in this species alone.

Arthur, J. C. (1925) .. .. North Amer. Fl. **7** : 695

Arthur, J. C. and Cummins, G. B. (1936). *Philip. J. Sci.* **61**: 473-474

Dietel, P. (1928) .. .. Die natürlichen Pflanzenfamilien **6** : 43

Mundkur B. B. and Thirumalachar M. J. (1946) *Mycol. Pap. Imp. Mycol. Inst.* **16** : 8

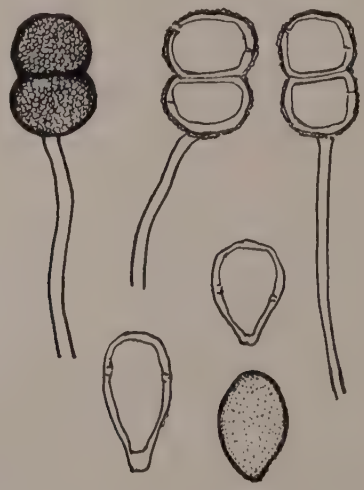


Fig 32 Cumminsiella

36. **CUMMINSIELLA** Arthur in *Bull. Torrey Bot. Cl.* **60**, p. 475, 1933. Fig. 32.

Pycnia subepidermal, punctiform with ostiolar paraphyses. Aecia subepidermal, cupulate with peridia. Uredia without paraphyses ; urediospores with equatorial germ pores or disposed in 2-series, pedicellate. Telia subepidermal, dark-brown ; teliospores ellipsoid, *Puccinia*-like, of 2 equal cells, pedicellate, with two lateral germ pores in each cell.

TYPE SPECIES : *Cumminsiella sanguinea* (Peck) Arthur on *Berberis atrocarpa*. (Berberidaceæ)

DISTRIBUTION : Europe, United States and South America (4 species)

NOTES : The rust resembles *Puccinia* in possessing subepidermal pycnia, peridiate æcia and 2-celled teliospores. The disposition of the germ pores in the urediospores and teliospores and the laminate wall of the teliospores indicate close relationship with *Uropyxis*. The genus *Cumminsiella* was established, however, to accomodate those species of *Uropyxis* with subepidermal pycnia in contrast to subcuticular condition in *Uropyxis*.

Arthur, J. C. (1934) .. .. Manual of Rusts, p. 74

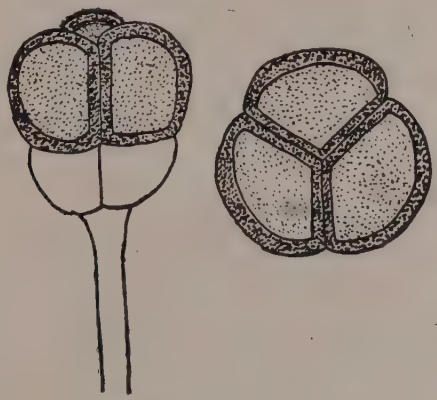


Fig. 33. Cystomyces

37. **CYSTOMYCES** Sydow in *Ann. Mycol.* **24** , p. 290, 1926. Fig. 33.

Pycnia subepidermal, applanate and conoid. Aecia and uredia unknown. Telia subepidermal, erumpent ; teliospore 3-celled, laterally united to form triangular heads, each cell possessing a hyaline cyst on the underside ; these combined into a hemispherical cushion ; pedicel simple, hyaline, attached to the cyst.

TYPE SPECIES : *Cystomyces costaricensis* Sydow on an undetermined species of Leguminosæ

DISTRIBUTION : Costa Rica (1 species)

NOTES : This rust is a short cycled species. Sydow and Dietel emphasize that the presence of simple pedicel in *Cystomyces* is an important diagnostic character, separating it from *Ravenelia*. The genus *Spumula* established by Mains for a rust on another legume from Mexico closely resembles *Cystomyces*. In both, teliospores are laterally united and possess pendent cysts and simple pedicels. In *Spumula* the pedicels are attached to the teliospores whereas in *Cystomyces* they arise from the fused portion of the cyst.

Dietel, P. (1928) .. .. Die natürlichen Pflanzenfamilien **6** : 70

Mains, E. B. (1935) .. .. *Mycologia* **27** : 638-641

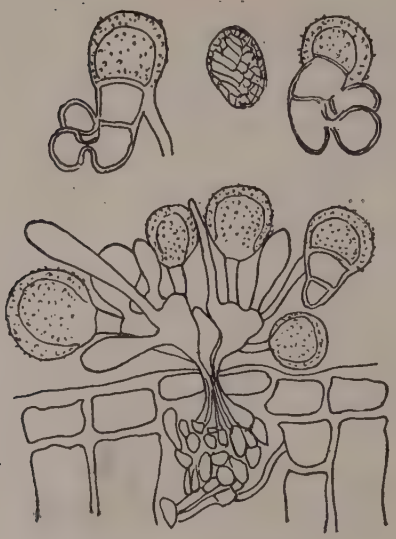


Fig. 34. Cystopsora

38. **CYSTOPSORA** Butler in *Ann. Mycol.* 8, P. 448, 1910. Fig. 34.

Pycnia subepidermal, flask-shaped. Aecia subepidermal, cupulate, without peridia. Uredia unknown. Telia subepidermal, sporogenous hyphæ emerging through stomata in fascicles, quite distinct, without lateral coalescence ; teliospores developing in clusters from basal generative cell formed at the apex of sporogenous hypha, germinating without a rest period towards the host ; sporidia sessile.

TYPE SPECIES : *Cystopsora oleæ* Butler on *Olea dioica* (Oleaceæ)

DISTRIBUTION : India and Australia (2 species)

NOTES : The genus was established by Butler for a rust with super-stomal telia and one-celled teliospores produced on basal cells or cysts and germinating by semi-internal 2-celled promycelium. Aecia had been noted by Butler but Ajrekar confirmed their occurrence by infection experiments. Thirumalachar in a restudy of the rust found that the teliospores are produced superstomally at the apex of sporogenous hyphæ which emerge out of the stomata. Butler stated that the promycelium was 2-celled bearing sessile sporidia but Thirumalachar found 4-celled promycelia also. In another collection made at Khandala, type locality, 2-and 4-celled promycelium were found in equal numbers.

In the closely allied monotypic genus *Zaghouania*, Dietel reports occasional occurrence of 2-celled promycelia under unfavourable conditions. Inoculation experiments conducted by Thirumalachar showed that the æciospores, if used to infect the same host, develop pycnia and secondary aecia, thus assuming the role, partly, of sporidia. Whether secondary aecia or telia develop following infection depends, it would appear, on the maturity of the host.

The genus is closely allied to *Zaghouania* also on an Oleaceous plant. The two differ in the structure of the telia. Butler discussed affinities of *Cystopsora* with *Ravenelia* and *Uromycladium* where the development of a cyst is a well established

character. But Thirumalachar pointed out that the structure referred to as "cyst" by Butler is a discoid generative cell. Relationship with *Zaghouania* and *Hemileia* is more evident.

Ajrekar, S. L. (1912) .. *Ann. Mycol.* **10** : 307-309
Dietel, P. (1923) .. .. *Ann. Mycol.* **21** : 86
Dietel, P. (1928) .. .. Die natürlichen Pflanzenfamilien **6** : 52
Sydow, P. & H. (1915) .. Monogr. Ured. III : 591-592
Sydow, H. (1937) .. .. *Ann. Mycol.* **35** : 351
Thirumalachar, M. J. (1945) *Bot. Gaz.* **107** : 74-86

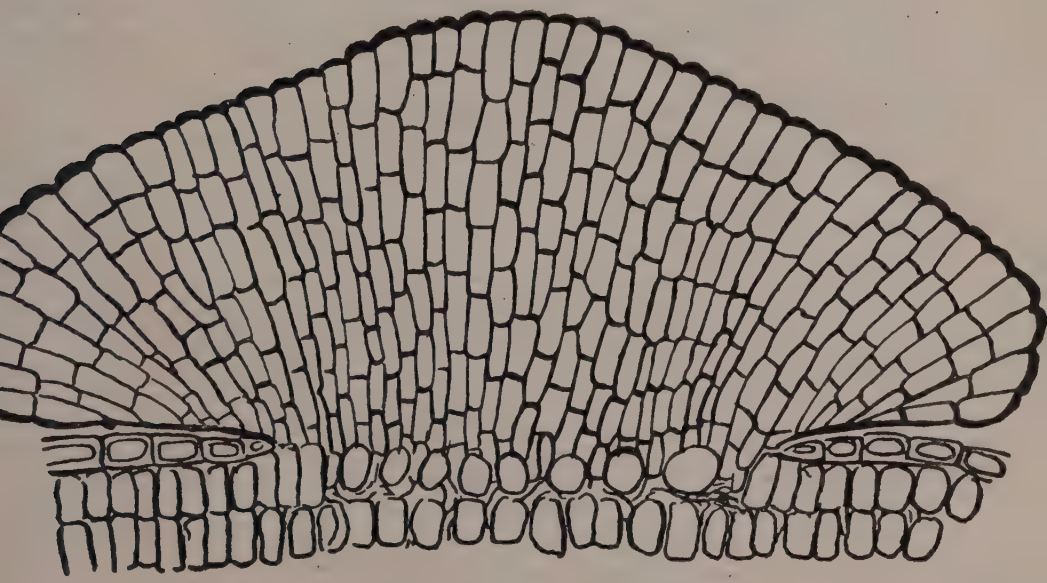


Fig. 35. Dasturella

39. **DASTURELLA** Mundkur and Kheswalla in *Mycologia*, **35**, p. 202, 1943. Fig. 35.

Pycnia subcuticular, conoid, without conspicuous ostiolar paraphyses. Aecia subepidermal, cupulate, with well developed peridia. Uredia subepidermal, erumpent, with marginal incurved paraphyses and sessile urediospores. Telia subepidermal, erumpent, reddish-brown, in flabelliform heads ; teliospores 1-celled, developed in basipetal catenations with the spores united both vertically and laterally to form

compact fasciculate crusts ; teliospores germinating after a period of rest by a 4-celled external promycelium.

TYPE SPECIES : *Dasturella divina* (Syd.) Mundkur and Kheswalla, on *Dendrocalamus strictus* (Gramineæ)

DISTRIBUTION : India, South Africa (3 species)

NOTES : The genus was based on a rust affecting the giant bamboo which Sydow had named *Angiopsora divina*. The telia are erumpent exposing a large flabelliform crust which distinguishes the genus from *Angiopsora* which is characterised by a non-erumpent, lenticular crust. As pointed out by Mundkur and Kheswalla, *Nothoravenelia* has telial heads which are successively formed and possess cysts and is therefore a separate genus. *Kweilingia* has been described by Teng as parasitic on bamboo. Its telia are stated to be crustose with 1-celled teliospores produced in chains and having lateral coalescence. Thirumalachar who examined the *type*, finds that it is not a rust.

Mundkur and Kheswalla reported the uredial and telial stages and characterised the teliospores as 2 to 6-celled. Thirumalachar *et al.* found the pycnial and æcial stages of *Dasturella divina* on *Randia dumetorum* and also noticed the teliospores to be one-celled and catenate.

Teng, S. C. (1940) .. .. .. *Sinensia* **2** : 105-130

Thirumalachar, M. J., *et al.* (1947) .. *Bot. Gaz.* **108** : 371-379

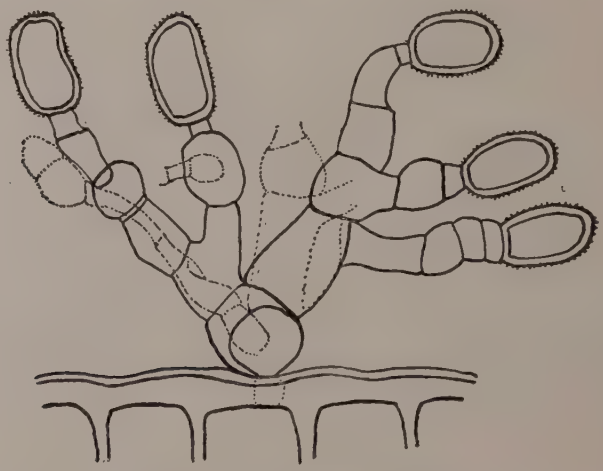


Fig. 36. Dasyspora. uredium.

40. **DASYSPORA** Berk. & Curt. in *J. Philadelphia Acad. Sci.* 2 ; II, p. 281, 1853. Fig. 36.

Syn. *Sartvellia* Berk. in *Intro. Crypt. Bot.* p. 317, 1857.

Pycnia subepidermal, globoid-hemispheric, with ostiolar filaments. Aecia unknown. Uredia *Oidium*-like, borne at the extermities of much branched multicellular hyphæ projecting through the stomata ; urediospores globoid or ellipsoid, with indistinct germ pores. Telia *Puccinia*-like, 2-celled, pedicellate.

TYPE SPECIES : *Dasyspora gregaria* (Kunze) P. Henn. (=*Dasyspora foveolata* Berk. & Curt.) on *Xylopia frutescens* (Anonaceæ)

DISTRIBUTION : British Guiana, Honduras, Brazil (one species)

NOTES : A detailed study of the rust is given by Mains. The rust was first distributed by Weigelt under the name *Puccinia gregaria* Kunze from Surinam, Br. Guiana. Berkeley and Curtis proposed a new genus *Dasyspora* for a rust on an unknown host from Surinam with *Dasyspora foveolata* as the type. Hennings showed that the rust possessed uredia of a type distinct from *Puccinia* and since *Puccinia gregaria* Kunze was validly described, proposed the name *Dasyspora gregaria*. Arthur considered the uredia described by Berkeley and Curtis as æcia and applied the name *Dasyspora* to all short cycled species of *Puccinia*. Hennings and others have shown the presence of uredia in the rust. Mains states that the uredia macroscopically resemble a Hyphomycete and the statement accompanying Weigelt's specimen as "*Oidium parasticum*" refers to the uredia.

The genus is not recognised by Dietel, Clements and Shear, and Sydow who reduce it to synonymy of *Puccinia*. But the uredia are so unlike those of any known rust that it deserves separate generic rank. In his later work Sydow (1925) recognises the genus and gives an illustration of the uredia. It has been accepted by Arthur also (see his Plant Rusts p. 141, 1929.)

Arthur, J. C. (1907) .. .. North Amer. Fl. **7** : 807

Arthur, J. C. (1906) .. .. *Result. Sci. Congr. Inter. Bot. Vienna*, p. 346

Clements, F. E. and Sheal C.L. (1931) .. The Genera of Fungi. p. 336.

Dietel, P. (1928) .. .. Die natürlichen Pflanzenfamilien **6** : 84

Hennings, P. (1896) .. .. *Hedwigia* **35** : 230-231

Mains, E. B. (1935) .. Carnegie Inst. Washington. No. 461, p. 93-106

Sydow, P. & H. (1915) .. Monogr. Ured. III, p. 2, 1915

Sydow, H. (1925) .. *Mycologia* **17** : 260

NOTES

From a press note issued by the Madras Government, it would appear that stem-rot due to *Sclerotium oryzæ* Catt. has appeared as a serious epiphytotic in the Mannargudi Taluka of the Madras Province. This fungus which was investigated at Pusa several years ago, failed to parasitise paddy plants and to produce the typical stem-rot symptoms in pot or field experiments ; it was then concluded that it is non-pathogenic under Indian conditions. Later Luthra and Sattar found that *Sclerotium oryza* caused typical stem-rot at Kalashakaku, near Lahore. The appearance of stem-rot in the Tanjore delta in an epiphytotic form shows that extremely parasitic races of the fungus that can cause typical stem-rot and death of the plants, exist or have appeared in India. This disease which has been investigated in detail by Tullis, Cralley and their colleagues in Arkansas and Louisiana, has been controlled by burning rice stubble and straw in paddy fields.

Dropping of immature orange and lime fruits in citrus orchards is a rather serious problem in many of the citrus growing sections of India. Citrus fruit-drop in California has, it would appear, been effectively reduced by adding 2, 4-D to sprays and it is claimed that even mature leaf-drop, fruit-stem die-back and black-button formation during citrus storage, are effectively reduced by this treatment.

Pure 2, 4-D is an organic acid which is only slightly soluble in water. To make it dissolve, it is usually prepared as a salt of which the ammonium and sodium salts are solids. The organic, alkanolamine, salts (diethanolamine, triethanolamine), are liquids. If 2, 4-D is used as a salt, it becomes effective at a concentration of 8 parts per million but as an ester, the concentration should be 250 p.p.m. Plant pathologists in India will no doubt give this substance a thorough trial, if these diseases are present in their citrus growing regions.

Virus diseases affecting potato crops have reduced yields to such an extent that potato cultivation has become very unprofitable in some parts of India. Reducing the aphid population in potato fields, it is claimed, may considerably help in controlling these diseases by reducing secondary infection. That is especially so if certified seed has been used.

Very effective insecticides for reducing aphid populations are now available. Five per cent DDT applied at the rate of 41 lbs. to the acre is stated to be extremely effective. BHC (Benzene hexachloride) though a good aphicide is not recommended by American Pathologists because it imparts a disagreeable odour and taste to the tubers. Parathion applied at the rate of 44 lbs. per acre has been found to be the best aphicide but this organic phosphate is highly toxic to man and insects alike. Another aphicide that has been recently developed is E. 605 (diethyl paranitrophenyl thiphosphate) and promises to by very popular.

Planting clean seed at the proper season, early recognition of potential aphid population and prompt spraying of plants with aphicides at the right stage of development, are cardinal rules that must be followed if any success is to be hoped for in the prevention of virus diseases in potato fields.

MINUTES OF THE SECOND ANNUAL MEETING HELD ON JANUARY 2, 1949 IN THE BOTANY HALL, UNIVERSITY OF ALLAHBAD, ALLAHBAD

Nine members and three visitors were present. Dr R. K. Saksena was unanimously voted to the Chair.

1. The minutes of the first annual meeting held on January 2, 1948 at Patna were read and confirmed.

2. The Secretary-Treasurer read the report for 1948 which was unanimously adopted.

3. The ballot papers were opened and the following office bearers were elected for 1949 :

President	S. R. Bose
Vice-President	R. S. Vasudeva
Councillors	
Northern Zone	R. Prasada
Western Zone	M. K. Patel
Mid-Eastern Zone	K. C. Mehta
Eastern Zone	S. Y. Padmanabhan
Central Zone	M. J. Thirumalachar
Southern Zone	K. M. Thomas

5. Dr S. P. Raychaudhuri was elected auditor for 1949.

6. It was resolved to change the current account in the Lloyd's Bank into a Savings Bank Account.

7. The Secretary-Treasurer was authorised to purchase National Cash Savings Certificates for Rs. 5000/-.

8. It was unanimously resolved that a symposium be held annually with the Botanical Section of the Indian Science Congress, Indian Botanical Society and other Societies on some topic of common interest.

9. A resolution proposing a vote of thanks to the retiring Office Bearers was unanimously passed.

10. A vote of thanks to the Chairman of the Meeting was proposed and passed unanimously.

SECOND ANNUAL REPORT OF THE INDIAN PHYTOPATHOLOGICAL SOCIETY

I am submitting herewith the second annual report (for 1948) of the INDIAN PHYTOPATHOLOGICAL SOCIETY.

Up to January 10, 1948, the date line set for joining the Society as Charter Members, 156 had joined the Society. Admissions during the year were 47 bringing the total membership to 203. One person resigned during the year and the name of another who sent his admission fee and subscription for 1947 by Money Order, is still untraceable. His M.O. was received in my absence and the clerk who received it did not note down the name written on the money order form.

The membership now stands at 201, of whom one is a patron, 26 are Life-Members and the rest are Ordinary Members. Of the last mentioned, 34 have yet to pay their 1948 dues. I hope that most of them would pay them along with their 1949 subscriptions.

One of the main objects of the Society is that of publishing its Journal, INDIAN PHYTOPATHOLOGY. Due to difficulties in getting the services of a suitable press, there has been unforeseen delay. I am glad to say that a good press has undertaken to do the work and all the required formalities have been gone through.

The financial position of the Society is at present sound. The year began with a balance of Rs. 5,331-11-0, and collections during the year amounted to Rs. 3,218. A sum of Rs. 496-3-3 was spent during 1948 on postage, printing, stationery, clerical charges, bank's commission, etc. A sum of $ 37.50 and £1-10-0 is in the course of collection by the bank from the U.S.A. and U.K. respectively, and will be credited to the Society's account. The sum in the bank at present is therefore Rs. 7,943-15-0, and in hand Rs. 53-12-9. It is proposed to purchase National Cash Certificates for the value of Rs. 5,000/- to cover the subscriptions from Patrons and Life-Members and a resolution to that effect is before you on the agenda for your approval.

With the starting of the Journal, the payments to the Press will start and balance will diminish. All the members are therefore requested to persuade their colleagues and students to join the Society. If we have a large membership, it will be possible to increase the issues of INDIAN PHYTOPATHOLOGY to four a year. Members are further urged to see that the Libraries of their Colleges, Institutes or Universities, as the case may be, subscribe to the JOURNAL.

As a result of persistent endeavour, several Mycologists and Pathologists from U.K., U.S.A. and Canada and even Norway, have enrolled as members. This campaign to get more members will be intensified in 1949 by sending them sample copies of the Journal. Members are requested to send the names of their friends and others abroad who may be interested in joining the Society.

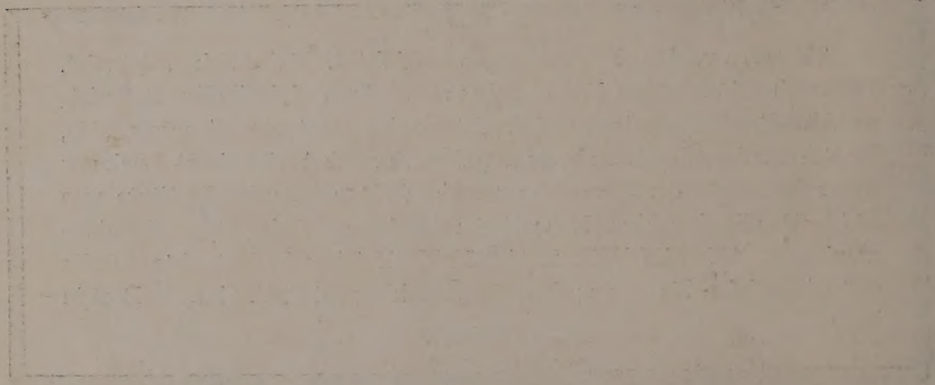
During the year under report, Dr R. Prasada gave me unstinted help in connection with the Society's work. I am grateful to him for that and I trust that he and his colleagues at the Indian Agricultural Research Institute will give increased help to make the Society worthy of Indian Mycologists and Pathologists.

The accounts of the Society have not been properly audited but I hope to get a Registered Accountant to audit the accounts both for 1947 and 1948 at no or very little cost. The balance sheet will be presented in Volume II, along with the Society's Annual Report.

B. B. MUNDKUR,
Secretary-Treasurer

R. K. SAKSENA,
President

There is a void in the Indian Botanical World. Birbal Sahni, Botanist, Philosopher, Patriot and Friend is no more. Dean of the Indian Botanists and Vice-President designate of the International Botanical Congress, 1950, Dr. Sahni succumbed to an heart attack on the 10th April 1949 at Lucknow where the foundation stone of the world's only Palaebotanical Institute was laid by Pandit Jawaharlal Nehru, Prime Minister of India, only a few days previously. INDIAN PHYTOPATHOLOGY joins the Botanists of India and of the World in paying this tribute to his great Soul. May it Rest in Peace.



INDIAN PHYTOPATHOLOGICAL SOCIETY

Instructions to Authors

Membership in the INDIAN PHYTOPATHOLOGICAL SOCIETY is prerequisite to publishing in INDIAN PHYTOPATHOLOGY but the Editorial Board may relax this rule in the case of contributions of exceptional merit and communicated with a special recommendation by a member. The Editorial Board may invite distinguished scientists to contribute articles of interest to the Society.

Contributions should be on one side of the page, double spaced, with a 1-1/4th inch margin on the left. In form and style, such as punctuation, spelling and use of italics, the manuscript should conform to the best Journals in the U. K. and U.S.A. Authors should strive for a clear and concise style of writing. The name and address of the Institution at which the work was done should be cited immediately after the SUMMARY at the end of the article on left hand side. Tables should be numbered and each table should have a heading stating briefly its contents. References to literature should be made as foot notes *only* when four or fewer citations are given. If there are more, they should be listed under 'REFERENCES' at the end of the paper and referred to by date in brackets in the body of the article. Citations should give the name of the author (or authors), his (or their) initials year of publication and then the full title correctly, followed by the name of the Journals, volume number, a colon and page numbers. If the title is in a foreign language, then the diacretic signs and capitalization should be precisely as in the original. The names of the Journal should be as abbreviated in the WORLD LIST OF PERIODICALS, 2nd ed., 1934, but as that book may not be available to all, contributors are requested to give the titles in full. Abbreviating will, in that case, be done by the Editors. If an article has not been seen in original, then that fact should be clearly stated. An example citing is given below:—

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